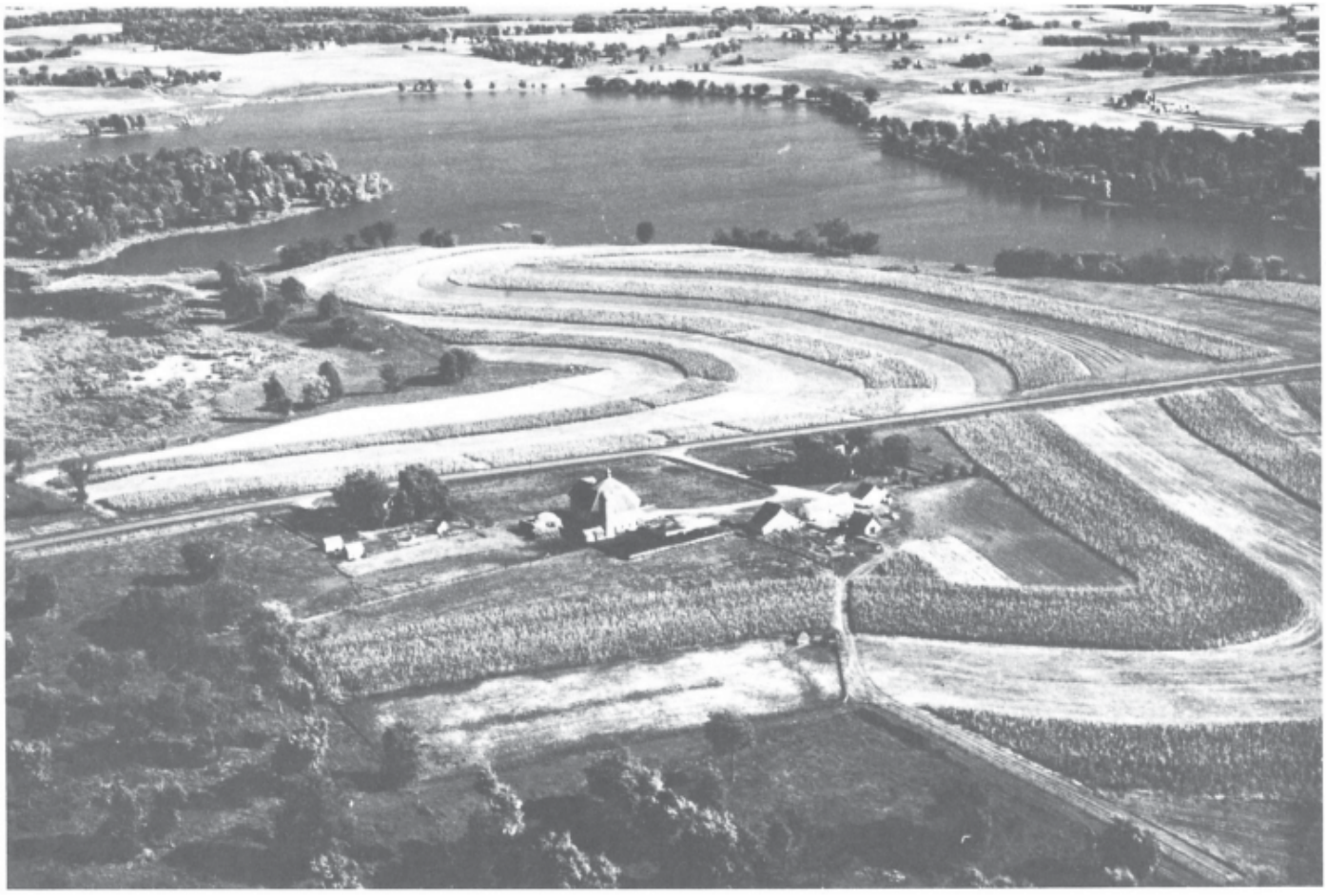
Issued November 1968

SOIL SURVEY

Carver County, Minnesota



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1950–62. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1966. This survey was made cooperatively by the Soil Conservation Service and the University of Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Carver County Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

All of the soils of Carver County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in this publication. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit, woodland group, and building site group in which the soil has been placed.

Individual colored maps showing the relative suitability or limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitation for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the descriptions of the soils and from the discussions of the capability groups and the woodland groups.

Foresters and others can refer to the section "Use of Soils for Woodland," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others concerned with wildlife can find information about soils and wildlife in the section "Wildlife Resources."

Community planners and others concerned with nonfarm development can read about the soil properties that affect the choice of homesites, industrial sites, schools, and parks in the section "Soils in Community Development."

Engineers and builders can find under "Soils in Engineering" tables that describe soil properties that affect engineering and that show the relative suitability of the soils for specified engineering purposes.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Carver County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Additional Facts About the County."

Cover picture

Contour strips and grass waterways on Lester loam, 6 to 12 percent slopes, eroded. Oak Lake in background.

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SOIL SURVEY OF CARVER COUNTY, MINNESOTA

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FIELD SURVEY BY GRENFALL F. HARMS, ROBERT A. LUETH, ROBERT C. MUNTER, PAUL R. NYBERG, AND RUSSELL J. EDWARDS, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

CARVER COUNTY, the third smallest county in Minnesota, is in the east-central part of the State (fig. 1). It has a total land area of 218,330 acres. The landscape is one of outwash plains and flats, gently rolling to steep hills, and many marshes and lakes. There are steep bluffs along the Minnesota River valley. Chaska, the county seat, is approximately 15 miles southwest of Minneapolis.

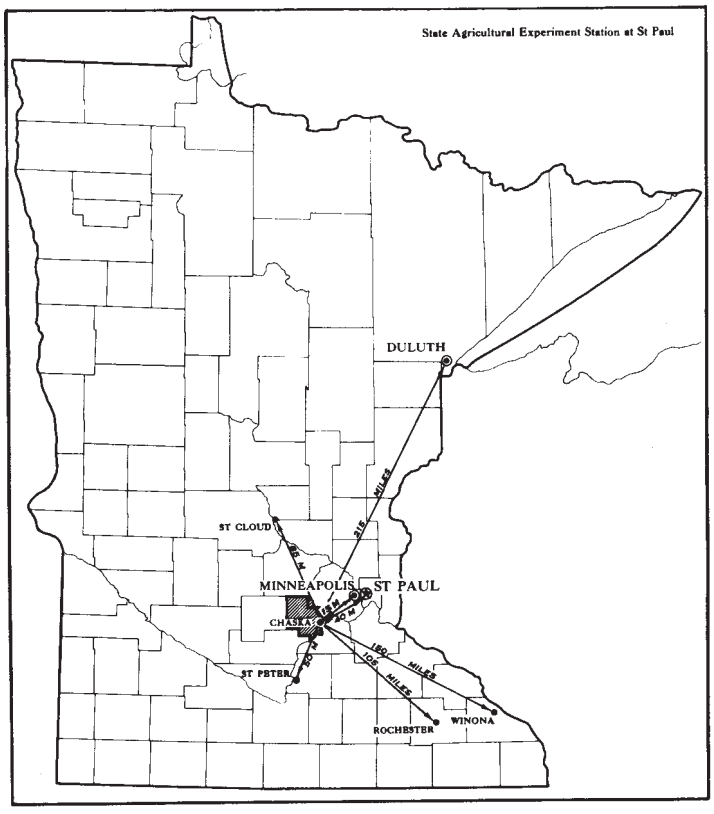


Figure 1.—**Location of Carver County in Minnesota.**

The county is mainly a farming area. The early settlers cleared timber and planted wheat and other small grain. Dairying was the leading enterprise in the early 1900's and is by far the most important today. The Grimm variety of alfalfa was developed in this county.

Suburban and rural-residential development is expanding in the eastern part of the county.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Carver County, where they are located, and how they can be used. They went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this survey efficiently, it is necessary to know the kinds of groupings most used in local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Hayden and Estherville, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the natural, undisturbed landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in the texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same tex-

ture belong to one soil type. Hayden clay loam and Hayden loam are two soil types in the Hayden series. The difference in the texture of their surface layers is apparent from their name.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Hayden loam, 6 to 12 percent slopes, is one of several phases of Hayden loam, a soil type that has a slope range of 2 to 40 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this survey was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed or occur in such small individual tracts that it is not practical to show them separately on the map. They show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Burnsville-Hayden complex.

Another kind of mapping unit is the undifferentiated group, which consists of two or more soils that may occur together without regularity in pattern or relative proportion. The individual tracts of the component soils could be shown separately on the map, but the differences between the soils are so slight that the separation is not important for the objectives of the soil survey. An example is Cordova and Webster silty clay loams.

Most surveys include areas where the soil material is so shallow, so rocky, or so frequently worked by wind and water that it cannot be classified by soil series. These areas are shown on the map like other mapping units, but they are given descriptive names, such as Sandy lake beaches or Sandy colluvial land, and are called land types.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field and plot experiments on the same kinds of soils. Yields under defined management are estimated for all of the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil surveys. The soil scientists set up trial groups based on the yield and practice tables and other data. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others; then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map in this publication shows, in color, the soil associations in Carver County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The eight associations in Carver County are described in the paragraphs that follow.

1. Cordova-Webster-LeSueur association

Nearly level to gently sloping, deep, moderately fine textured soils mainly on broad flats in the uplands

This association is characterized by broad flats and a few depressions and slight rises. The soils formed in loamy glacial till high in lime carbonates. The original vegetation was prairie grass, but most of the association was wooded and brushy at the time of settlement. One area of the association occurs in the southwestern corner of the county, south and west of Hamburg, and two smaller areas are in the northwestern part, northeast of New Germany and southeast of Hazelton. The association makes up approximately 6,000 acres, or about 3 percent of the county.

The dominant soils are the Cordova, Webster, and LeSueur. The Cordova and Webster soils are poorly drained, black, nearly level silty clay loams. The LeSueur soils are moderately well drained, black, gently sloping to nearly level clay loams. All have high moisture-storage capacity and natural fertility.

Less extensive in this association are the very poorly drained, silty Glencoe soils and Peat, which are in depressions and drainageways. Peat, which generally occupies the larger depressions, is variable in depth and is underlain by silty material.

This association is used mainly for dairy farming. Drained areas are excellent for crops. Corn and soybeans are major crops. The farms range from 40 to 240 acres in size; the average size is 100 acres. Most of the pastures are wet and partly wooded. There are small tracts of woodland, and many farms have small woodlots.

Draining the soils of this association is a problem because of the lack of suitable outlets. Most areas of Glencoe soils and Peat are too wet for crops. Extensive areas of Cordova and Webster soils have been tiled. Preserving tilth is a problem also.

2. *Lester-LeSueur-Peat association*

Gently rolling, deep, medium-textured to moderately fine textured soils in the uplands

This association is characterized by fairly smooth slopes, many depressions, and a few fairly broad flats. The flats are mostly in the southern part of the county. The soils formed in loamy glacial till under prairie grasses and hardwoods. This association, the second largest in the county, is in the western and southeastern parts. It makes up approximately 66,000 acres, or about 28 percent of the county.

Lester and LeSueur soils and Peat are dominant in this association. The Lester soils are undulating to moderately steep, deep, well-drained loams. They have a subsoil of clay loam that overlies calcareous loamy glacial till. The LeSueur soils are nearly level to gently sloping, moderately well drained clay loams. Both Lester and LeSueur soils have high moisture-storage capacity and high natural fertility.

Peat, which occupies most of the depressions, is generally 2 to 6 feet deep over moderately fine textured material. It has low natural fertility and high moisture-storage capacity. Some of the bogs are fairly extensive.

Less extensive soils in this association are the poorly drained Cordova and Webster soils, which are on flats and in the upper reaches of drainageways.

This association is used chiefly for dairy farming. Drained areas are very good for crops, mainly corn, oats, and alfalfa. Many of the smaller depressions have been artificially drained. The larger bogs, which are ordinarily too wet for crops, are used for pasture and wild hay. Most of the association is cleared, but wooded pastures and small woodlots are common. The average size of farms is 140 acres.

Drainage is needed throughout the association. Erosion is generally moderate in sloping areas. It is severe on some of the steeper slopes.

3. *Lester-Hayden-Peat association*

Rolling, deep, medium-textured to moderately fine textured soils in the uplands

This association is characterized by fairly long and smooth to short and irregular slopes, and by many lakes, marshes, and low wet bogs. The soils formed in loamy glacial till under broadleaf hardwoods and prairie grasses. This association extends through the central part of the county and occurs as small areas in the eastern part. It makes up approximately 87,000 acres, or about 37 percent of the county.

Lester and Hayden soils and Peat are dominant in this association. The Lester and Hayden soils are well-drained loams that have a subsoil of clay loam. They generally are leached of lime to a depth of 30 to 40 inches. Their moisture-storage capacity and natural fertility are moderately high.

The Lester soils have a relatively thick, dark-colored surface layer. The Hayden soils, in contrast, have a thinner surface layer. The Hayden soils generally are more strongly sloping than the Lester soils.

Peat is variable in depth and in most places is underlain by silty material. It occupies most of the depressions.

Less extensive soils in this association are the poorly drained Cordova and Webster soils, which are in draws and on flats, and the moderately well drained, nearly level to gently sloping LeSueur soils.

This association is used mainly for dairy farming. It is also good for crops. Corn, oats, and alfalfa are the principal crops. Pasture grasses and wild hay grow in the low, wet meadows and bogs. Most farms are approximately 100 acres in size, but some in the central part of the county, particularly in Benton and Waconia Townships, are more than 125 acres. Most of the acreage is cleared. There are a few scattered wooded pastures and small woodlots.

Drainage is needed throughout the association. Erosion is moderate to severe in cultivated areas.

Suburban developments in the eastern part of the county are rapidly expanding into this association.

4. *Hayden-Lester-Peat association*

Strongly rolling to hilly, deep, medium-textured to moderately fine textured soils in the uplands

This association is characterized by irregular strong slopes and hills (fig. 2), depressions, and many lakes, marshes, and bogs. The soils formed under hardwoods in loamy glacial till high in lime carbonates. This association is mainly in the northeastern part of the county. It makes up approximately 46,000 acres, or about 20 percent of the county.

Hayden and Lester soils and Peat are dominant in this association. The Hayden and Lester soils are deep, well-drained loams that have a subsoil of brownish clay loam. Hayden soils are the most extensive. Peat, which occupies most of the depressions, is generally more than 3 feet deep.

Less extensive soils in this association are the poorly drained Webster soils, which are in drainageways.

***Figure 2.*—Strongly rolling to hilly Hayden soils on association 4.**

This association is used intensively for dairy farming. The less sloping areas are good for crops. About equal acreages are in corn, oats, alfalfa hay, and pasture. The average size of farms is only about 90 acres, but there are a number of dairy farms between 300 and 500 acres in

size. Also, there are many estate-type farms and homes near Lake Minnetonka, Lake Minnewashta, and other lakes in the association.

Much of the association is too steep to be used for crops and should be kept in permanent vegetation. Erosion is moderate to severe. The Hayden soils are hard to keep in good tilth because of the low organic-matter content. Drainage is needed throughout the association.

Suburban developments in the eastern part of the county are expanding rapidly into this association. Land development companies have purchased large tracts for residential purposes.

5. *Mayer-Estherville-Talcot association*

Nearly level to gently undulating, medium-textured soils moderately deep to shallow over sand and gravel; on outwash plains along the South Fork Crow River

This association is on fairly broad flats and in depressions and drainageways. The soils formed under prairie grasses and marsh bunch grasses. This association occurs in the northwestern part of the county. It makes up approximately 8,000 acres, or about 4 percent of the county.

The dominant soils are the Mayer, Estherville, and Talcot. The Mayer soils, which are the most extensive, are poorly drained loams on flats. They have a subsoil of loam or sandy clay loam and, at a depth of 24 to 36 inches, a gravelly substratum. Fairly extensive areas of the droughty Estherville soils also occur on the flats. These soils have a surface layer of sandy loam or loam and have sand and gravel within a depth of 12 to 24 inches. The silty, very poorly drained Talcot soils are in depressions and drainageways.

Less extensive in this association are the well-drained Wadena loams, which are 24 to 36 inches deep over a coarse substratum, and bottom lands that are subject to flooding.

Dairying is the main type of farming on this association. The Estherville soils are used chiefly for corn and oats, and the other soils for pasture and hay. The average size of the farms is 85 acres. About half the farms on this association are between 40 and 50 acres in size.

Draining the Mayer and Talcot soils is a major problem because of the lack of suitable outlets and because of caving of the substratum. Droughtiness is a serious limitation, particularly on the Estherville soils.

6. *Fairhaven-Kasota-Estherville association*

Nearly level to strongly rolling, medium-textured soils moderately deep to shallow over sand and gravel; on outwash terraces above the Minnesota River

This association is characterized by broad flats, strongly rolling outwash terraces (fig. 3), and many wet depressions. It is bordered on the west by association 3, which is at a higher elevation, and on the other sides by the steep hills and bluffs of association 7, which borders the Minnesota River valley. The soils vary widely in texture, or from loamy sands to silty clay loams, and in depth to sand and gravel. The original vegetation was prairie grass, but hardwoods encroached, and the area was wooded and brushy at the time of settlement. This association makes up approximately 6,000 acres, or about 3 percent of the county.

The dominant soils are the Fairhaven, Kasota, and Estherville. The well-drained Fairhaven and Kasota soils are nearly level to gently sloping. The droughty Estherville soils are more rolling than the Fairhaven and Kasota soils.

The Fairhaven and Kasota soils are loams or silt loams that are underlain by sand and gravel within a depth of 24 to 42 inches. The Fairhaven soils are the more silty. The Kasota soils have a clayey subsoil. These soils have high natural fertility and moderate to moderately high moisture-storage capacity. The Estherville soils are sandy loams or loams that are 12 to 24 inches deep over sand and gravel. The depressions contain deep, water-deposited clays. They are generally marshy and filled with water.

Less extensive in this association are the Rasset soils, which have a surface layer of loamy sand or sandy loam and a subsoil that varies in content of clay and grades to sand and gravel within a depth of 12 to 48 inches.

This association is used mainly for dairy farming. The Fairhaven and Kasota soils are very good for crops, chiefly corn, soybeans, and alfalfa. The average size of the farms is 95 acres.

Slight to severe droughtiness is the major limitation. Many of the soils are sandy but have a clayey subsoil that helps to retain water. Controlling wind erosion is a serious problem on the sandy soils.

7. *Salida-Hayden association*

Very steep, coarse-textured to medium-textured soils on hills and bluffs

This association is on steep hills and bluffs bordering the Minnesota River valley and along streams that lead into that valley. It is characterized by many ravines and deep, broad gullies. Sand and gravel have been deposited at the base of the very steep slopes. This association makes up approximately 4,000 acres, or about 2 percent of the county.

The coarse-textured, droughty Salida soils, which are very shallow over sand and gravel, are the most extensive. They generally occur where the association borders association 6. The steep soils bordering association 4 are generally the deep Hayden loams.

This association is too steep and too severely eroded to be used for crops, and in most places it is poor for pasture. Much of it is wooded. No farm is entirely within this association. Most of the acreage is a part of farms that are on other associations.

Permanent vegetation and engineering structures are needed for erosion control.

8. *Alluvial land-Chaska-Oshawa association*

Chiefly medium-textured to moderately fine textured soils on flood plains along the Minnesota River

This association is characterized by short, narrow ridges and wet, marshy basins. The landscape appears to be corrugated. This association is at the southeastern edge of the county, along the Minnesota River. It makes up approximately 6,000 acres, or about 3 percent of the county.

Alluvial land and the Chaska and Oshawa soils are dominant in this association. Alluvial land is generally loamy but varies in texture and also in color. The Chaska soils are poorly drained, dark-gray silty clay loams. The Oshawa soils are very poorly drained silty clay loams in drainage channels and basins.

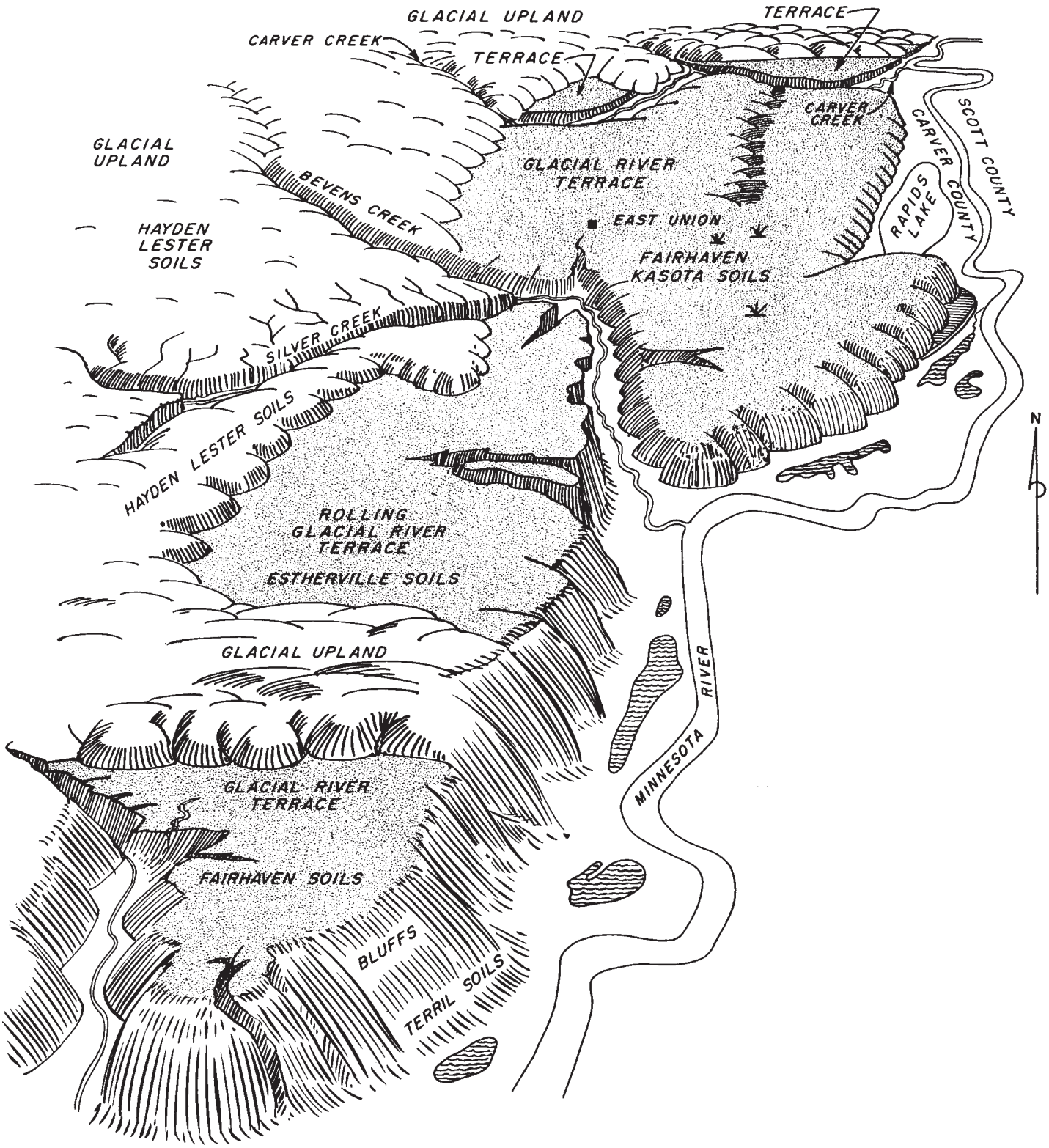


Figure 3.—**Outwash terraces along Minnesota River.**

Some fields on this association are at a high enough elevation to be good for crops, but extensive areas are frequently flooded and ponded and are suitable only for pasture. No farm is entirely within this association. Most of the acreage is a part of farms that are on other associations.

Flood prevention is needed, but even if flooding were controlled, the soils would need to be drained before they could be used for crops.

Descriptions of the Soils

This section describes the soil series and mapping units of Carver County. Figure 4 shows two views of the major upland soils in the county. Figure 5 shows the major soils and their underlying material. The approximate acreage and the proportionate extent of each mapping unit are given in table 1.

A general description of each soil series is given, and

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Alluvial land	2, 341	1. 0	Hubbard loamy sand, 2 to 6 percent slopes	323	. 1
Alluvial land, frequently flooded	3, 230	1. 4	Hubbard loamy sand, 6 to 12 percent slopes	235	. 1
Biscay loam	1, 278	. 6	Hubbard loamy sand, 12 to 18 percent slopes	226	. 1
Biscay loam, sandy subsoil variant	195	. 1	Hubbard loamy sand, 18 to 35 percent slopes	111	(1)
Burnsville-Hayden complex, 2 to 6 percent slopes	407	. 2	Hubbard sandy loam, 0 to 2 percent slopes	234	. 1
Burnsville-Hayden complex, 6 to 12 percent slopes	378	. 2	Hubbard sandy loam, 2 to 6 percent slopes, eroded	478	. 2
Burnsville-Hayden sandy loams, 12 to 18 percent slopes	236	. 1	Hubbard sandy loam, 6 to 12 percent slopes, eroded	216	. 1
Burnsville-Hayden sandy loams, 18 to 25 percent slopes	130	. 1	Hubbard sandy loam, 12 to 18 percent slopes	88	(1)
Canisteo silty clay loam	3, 241	1. 4	Kasota loam, 0 to 2 percent slopes	555	. 2
Canisteo silty clay loam, depressional	1, 175	. 5	Kasota loam, 2 to 6 percent slopes, eroded	189	. 1
Chaska silty clay loam	585	. 3	Kasota sandy loam, 0 to 2 percent slopes	230	. 1
Comfrey silty clay loam	743	. 3	Kasota sandy loam, 2 to 6 percent slopes, eroded	75	(1)
Comfrey silty clay loam, frequently flooded	555	. 2	Lester loam, 2 to 6 percent slopes	36, 316	15. 9
Cordova silty clay loam	6, 110	2. 7	Lester loam, 2 to 6 percent slopes, eroded	7, 823	3. 4
Cordova and Webster silty clay loams	18, 804	8. 2	Lester loam, 6 to 12 percent slopes	2, 422	1. 1
Dakota and Rasset sandy loams, 0 to 2 percent slopes	305	. 1	Lester loam, 6 to 12 percent slopes, eroded	8, 104	3. 5
Dakota and Rasset sandy loams, 2 to 6 percent slopes	281	. 1	Lester loam, 12 to 18 percent slopes, eroded	1, 399	. 6
Estherville sandy loam, 0 to 2 percent slopes	528	. 2	Lester-Estherville complex, 2 to 6 percent slopes	306	. 1
Estherville sandy loam, 2 to 6 percent slopes	1, 319	. 6	Lester-Estherville complex, 6 to 12 percent slopes, eroded	202	. 1
Estherville sandy loam, 2 to 6 percent slopes, eroded	409	. 2	LeSueur clay loam, 0 to 2 percent slopes	10, 025	4. 4
Estherville sandy loam, 6 to 12 percent slopes	189	. 1	LeSueur clay loam, 2 to 6 percent slopes	4, 304	1. 9
Estherville sandy loam, 6 to 12 percent slopes, eroded	590	. 3	Marsh	4, 485	2. 0
Estherville sandy loam, 12 to 18 percent slopes	390	. 2	Mayer loam	809	. 4
Estherville sandy loam, 18 to 25 percent slopes	160	. 1	Oshawa silty clay loam	379	. 2
Fairhaven silt loam, deep variant, 0 to 3 percent slopes	302	. 1	Peat and muck, calcareous	168	. 1
Fairhaven silt loam, sand substratum, 0 to 2 percent slopes	719	. 3	Peat and muck, deep	14, 758	6. 4
Fairhaven silt loam, sand substratum, 2 to 6 percent slopes	386	. 2	Peat and muck, moderately shallow, over loam	7, 659	3. 3
Fairhaven silt loam, sand substratum, 6 to 12 percent slopes, eroded	97	(1)	Peat and muck, moderately shallow, over sand	4, 700	2. 1
Glencoe silty clay loam	16, 738	7. 3	Rasset loamy sand, 0 to 6 percent slopes	449	. 2
Hayden clay loam, 6 to 12 percent slopes, severely eroded	276	. 1	Rasset loamy sand, 6 to 12 percent slopes	209	. 1
Hayden clay loam, 12 to 18 percent slopes, severely eroded	1, 752	. 8	Rasset loamy sand, 12 to 18 percent slopes	114	(1)
Hayden clay loam, 18 to 25 percent slopes, severely eroded	851	. 4	Salida loamy sand, 18 to 40 percent slopes	1, 620	. 7
Hayden loam, 2 to 6 percent slopes	7, 559	3. 3	Sandy colluvial land	172	. 1
Hayden loam, 2 to 6 percent slopes, eroded	3, 536	1. 5	Sandy lake beaches	2, 352	1. 0
Hayden loam, 6 to 12 percent slopes	4, 033	1. 8	Storden-Lester loams, 6 to 12 percent slopes, eroded	390	. 2
Hayden loam, 6 to 12 percent slopes, eroded	8, 949	3. 9	Storden-Lester loams, 12 to 18 percent slopes, eroded	247	. 1
Hayden loam, 12 to 18 percent slopes	2, 317	1. 0	Talcot silty clay loam	781	. 3
Hayden loam, 12 to 18 percent slopes, eroded	2, 505	1. 1	Terril loam, 0 to 6 percent slopes	3, 378	1. 5
Hayden loam, 18 to 25 percent slopes, eroded	1, 708	. 7	Terril loam, 7 to 11 percent slopes	189	. 1
Hayden loam, 25 to 40 percent slopes	3, 692	1. 6	Terril loam, occasionally flooded	457	. 2
Hubbard loamy sand, 0 to 2 percent slopes	98	(1)	Wadena loam, 0 to 2 percent slopes	1, 027	. 4
			Wadena loam, 2 to 6 percent slopes	712	. 3
			Wadena loam, 6 to 12 percent slopes, eroded	140	. 1
			Gravel pits	177	. 1
			Total land area	218, 330	95. 3
			Total water area	10, 790	4. 7
			Total	229, 120	100. 0

[1] Less than 0.05 percent.

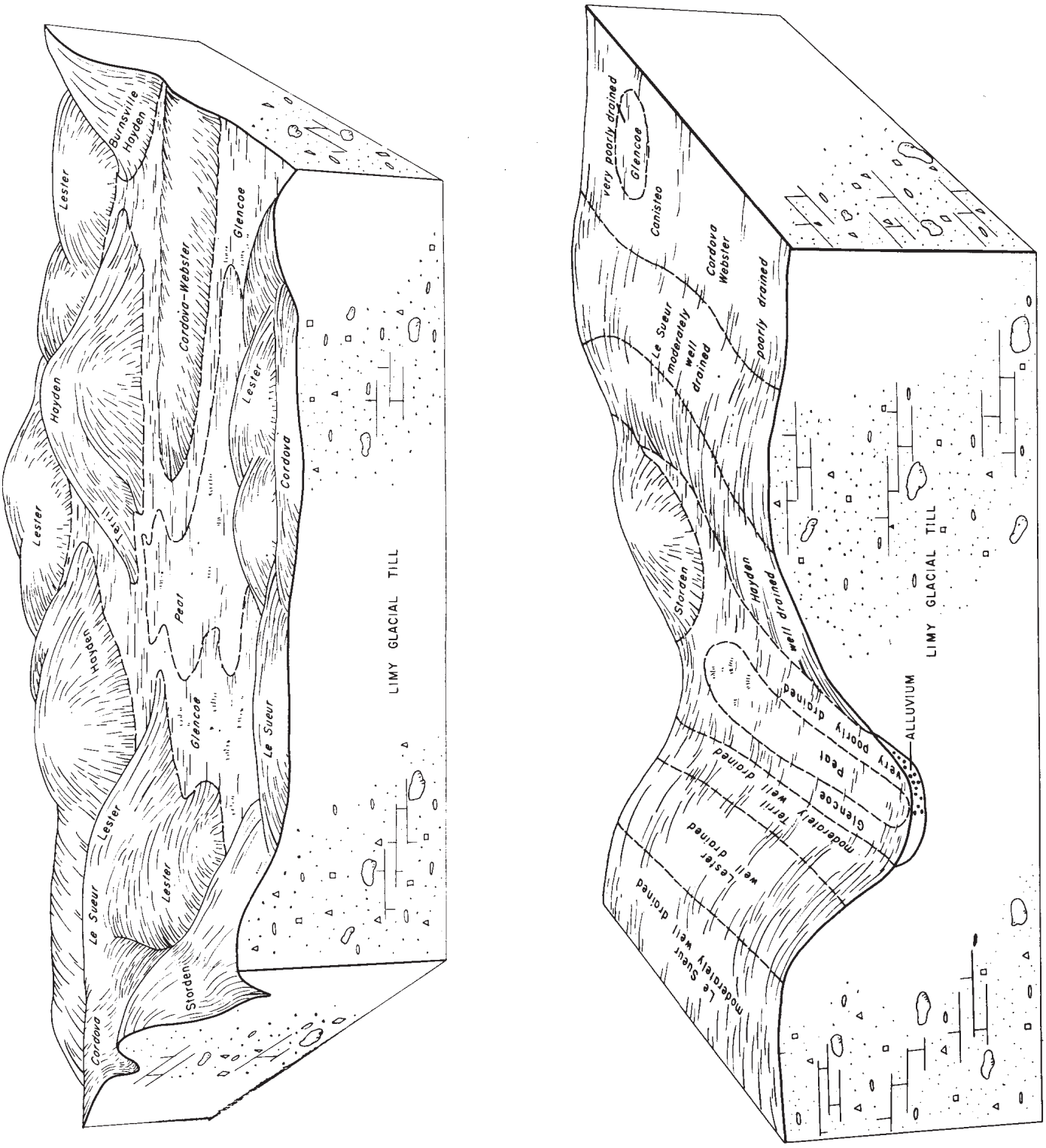


Figure 4.—Two views of major upland soils in Carver County.

286-417—68——2

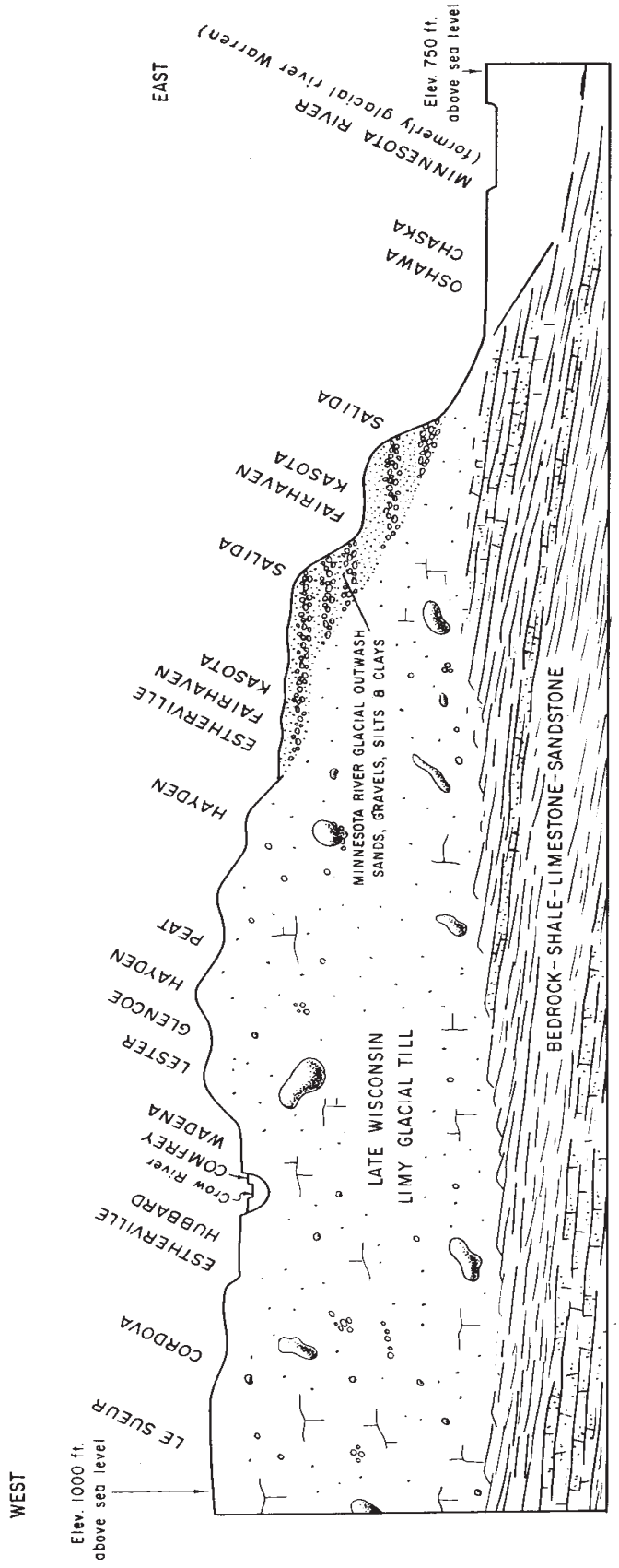


Figure 5.—Major soils and underlying material.

this is followed by brief descriptions of the mapping units in that series. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of the description of each mapping unit are the capability unit, the woodland group, and the building site group in which the mapping unit has been placed. The page on which each capability unit, each woodland group, and each building site group is described can be found readily by referring to the "Guide to Mapping Units" at the back of this publication.

Soil scientists, engineers, students, and others who want detailed descriptions of soil series should turn to the section "Formation and Classification of the Soils." Many terms used in the soil descriptions and other sections of the publication are defined in the Glossary.

The color descriptions are for moist soil, unless otherwise stated. All pH determinations were made on undried samples by means of a Hellige-Truog soil reaction tester.

Alluvial Land

Alluvial land consists of areas of stratified alluvium recently deposited by streams on flood plains. These areas are fairly extensive along the Minnesota River and other streams of the county. Many are dissected by old stream channels and consequently have short narrow ridges and appear to be corrugated.

The alluvium varies widely in texture, color, and reaction and is subject to frequent change resulting from stream overflow, scouring, and changes in stream channels. It is faintly to distinctly mottled.

Alluvial land (0 to 6 percent slopes) (Al).—Alluvial land is moderately well drained. It is flooded occasionally.

The soil material varies widely in texture but is typically sandy loam and loam stratified with sand. It is neutral to medium alkaline. Natural fertility is moderate to moderately high. The water table is seasonally high.

Alluvial land lacks the uniformity in color, texture, and reaction that is typical of Terril loam, occasionally flooded.

This land type is fairly good to good for crops and pasture. It is used mainly for corn and soybeans. The hazard of flooding is the most serious limitation. Floodwater is likely to delay planting in spring but generally recedes early enough to permit cropping. Occasionally it destroys crops in June. (Capability unit IIw–2; woodland group 8; building site group 11)

Alluvial land, frequently flooded (0 to 6 percent slopes) (Au).—This land type ranges from well drained to very poorly drained. Some areas are ponded throughout the year.

The soil material varies widely in texture but is typically loamy or silty and is stratified with moderately sandy material. It is neutral to medium alkaline. The water table is seasonally high.

Alluvial land, frequently flooded, occurs in lower channels and lower lying positions on the flood plain than Alluvial land. It is also more silty and has a higher water table.

This land type is not suitable for crops unless protected from flooding. It is fairly good to good for pasture. (Capability unit VIw–1; woodland group 9; building site group 11)

Biscay Series

The Biscay series consists of loamy, poorly drained soils that are moderately deep over limy sand and gravel. These soils occupy flats and drainageways on outwash plains and stream terraces. The native vegetation was grass. The acreage in this county is inextensive.

The surface layer is black, friable loam. It is about 13 inches thick, is neutral, and has weak, fine granular structure. The subsurface layer is about 6 inches thick and is slightly lighter colored than the surface layer.

The subsoil is about 12 inches thick. It is friable, is neutral, and lacks structure. The upper part is olive-gray loam that has few, faint, olive mottles. The lower part is sandy loam that has many, prominent, olive mottles.

The underlying material consists of loose, olive and olive-gray, limy gravel and coarse sand.

Natural fertility is moderately high. The organic-matter content is high. Runoff is slow, permeability is moderately rapid, and the moisture-storage capacity is moderate. The water table is fairly high.

Drained areas are suited to all of the common crops. Undrained areas are used mainly for pasture.

Typical profile of Biscay loam (bluegrass pasture; 1 percent slope; NW¼NW¼ sec. 17, T. 116 N., R. 26 W.):

A11—0 to 10 inches, black (N 2/0 10YR 2/1) loam; weak, fine, granular structure; friable when moist; neutral; gradual, smooth boundary.

A12—10 to 13 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable when moist; neutral: clear, smooth boundary.

A3—13 to 19 inches, very dark gray (10YR 3/1) loam: weak, fine, granular structure; friable; neutral: clear, smooth boundary.

B1g—19 to 27 inches, olive-gray (5Y 5/2) loam; few, fine, faint mottles of olive gray (5Y 4/2) and olive (5Y 5/3); massive; friable when moist; neutral; clear, smooth boundary.

B2g—27 to 31 inches, olive-gray (5Y 5/2) loam grading to sandy loam; many, medium, prominent mottles of olive (5Y 5/3); massive; friable when moist; neutral; clear, smooth boundary.

C—31 to 45 inches, variegated olive (5Y 5/3 and 5/4) and olive-gray (5Y 5/2) gravel and coarse sand; single grain; loose; many lime concretions; calcareous.

The A horizon ranges from 12 to 20 inches in thickness. The B horizon is typically loam but ranges from sandy loam to clay loam. Both the A and B horizons are neutral or slightly acid. Depth to the calcareous gravel and sand ranges from 24 to 42 inches.

Biscay soils are closely associated with the well-drained Wadena soils and the somewhat excessively drained Estherville soils. They differ in reaction from the poorly drained Mayer soils, which are calcareous throughout the solum. They have a thinner surface layer than that of the very poorly drained Talcot soils.

Biscay loam (Bc).—This soil is on flats and in slight depressions. Included in mapping were small areas where the surface layer is silt loam or silty clay loam and a few spots where it is limy.

Excess water is a moderate limitation. Drained areas are good for corn and soybeans. Undrained areas are used mainly for pasture and wild hay. (Capability unit IIw–1; woodland group 8; building site group 9)

Biscay Series, Sandy Subsoil Variant

The Biscay series, sandy subsoil variant, consists of loamy, poorly drained soils. These soils differ from Biscay loam in that they are moderately deep over limy sand instead of sand and gravel. They occupy flats and drainageways on outwash plains and stream terraces. The native vegetation was grass.

The surface layer is black, friable loam. It is about 13 inches thick and has moderate blocky structure. The upper part is slightly acid. The lower part is neutral. The subsurface layer is very dark gray, friable sandy clay loam. It is massive, and is about 6 inches thick. This layer is neutral.

The subsoil is massive, and is about 23 inches thick. It is neutral. The uppermost part is dark-gray, friable sandy clay loam. The middle part is olive-gray and olive sandy clay loam. The lowermost part is olive-gray and olive, very friable loamy sand.

The limy underlying material is olive-gray and light olive-gray, loose sand and coarse sand that contains a small amount of fine gravel.

Natural fertility is moderately high. The organic-matter content is high. Runoff is slow, permeability is moderately rapid, and the moisture-storage capacity is moderate. The water table is seasonally fairly high.

Drained areas are suited to all of the common crops. Undrained areas are used mainly for pasture.

Biscay loam, sandy subsoil variant (Bd).—This soil is on flats and in slight depressions. Included in mapping were spots where the surface layer is silty.

Excess water is a moderate limitation. Drained areas are very good for corn and soybeans. Undrained areas are used mainly for pasture and wild hay. (Capability unit IIw–1; woodland group 8; building site group 9)

Burnsville Series

The Burnsville series consists of loamy, rolling to hilly, somewhat excessively drained soils that are shallow over limy, sandy and gravelly glacial till. The original vegetation consisted of deciduous hardwoods. The topography is irregular and morainic. Most of the acreage in this county is in the eastern part.

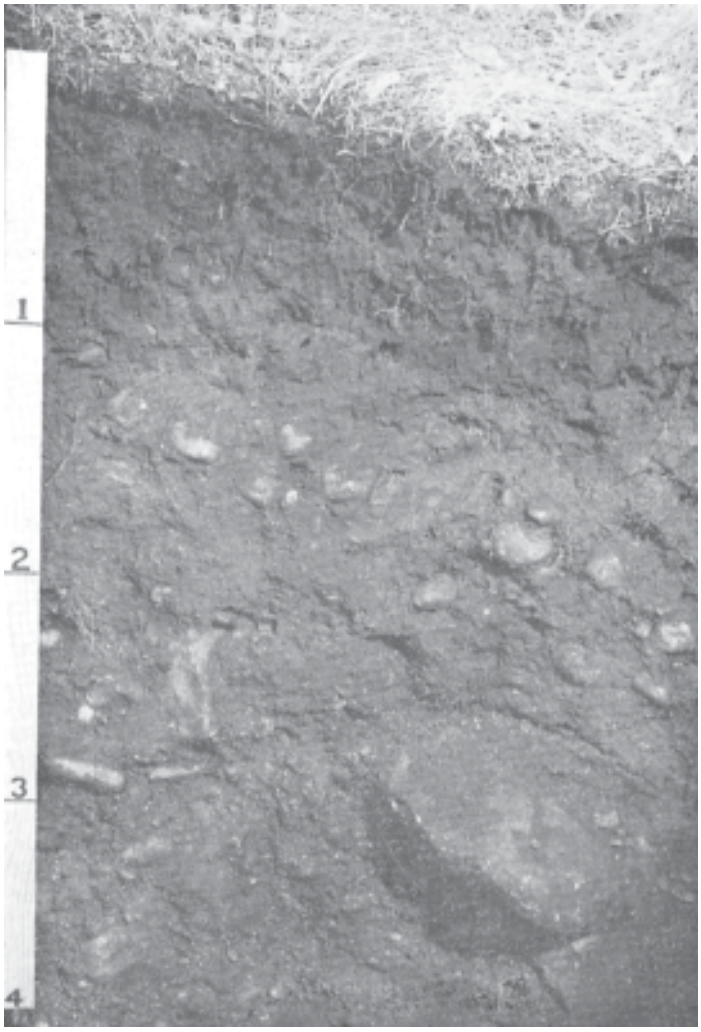
The surface layer is very dark gray, friable sandy loam. It is about 4 inches thick, is slightly acid, and has moderate granular structure. The subsurface layer is about 2 inches thick. It is lighter colored than the surface layer and has weaker structure.

The subsoil is about 16 inches thick. The uppermost part is dark grayish-brown, friable sandy loam. It is slightly acid and has weak blocky structure. The middle part is coarse sandy loam. The lowermost part is loamy coarse sand and coarse sandy loam. It is massive, is slightly acid, and contains dark-brown stones and cobblestones.

The underlying material consists of grayish-brown, loose sand, gravel, stones, and cobblestones (fig. 6).

In this county Burnsville soils are mapped only with Hayden soils. For a description of the Hayden part of the following mapping units, refer to "Hayden Series."

These soils warm up early in spring and dry out rapidly after a rain. Natural fertility is low. The organic-matter content is low. Runoff is medium to rapid, depending on the slope. Permeability is moderately rapid to rapid, and the moisture-storage capacity is low. The root zone is limited.



Burnsville soils are used for general farming. They are too droughty to be used for corn. The less sloping parts are suited to small grain. The steeper parts, which are subject to severe erosion, are used mainly for hay and pasture.

Typical profile of Burnsville sandy loam (wooded pasture; 5 percent slope):

A1—0 to 4 inches, very dark gray (10YR 3/1) sandy loam; moderate, fine and medium, granular structure; friable; high organic-matter content; slightly acid; clear, smooth boundary.

A2—4 to 6 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) sandy loam; weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

B21—6 to 12 inches, dark grayish-brown (10YR 4/2) to dark-brown (10YR 4/3) sandy loam; weak, fine and very fine, subangular blocky structure; clay bridging; friable and slightly sticky; slightly acid; clear, smooth boundary.

B22—12 to 16 inches, dark grayish-brown (10YR 4/2) to dark-brown (10YR 4/3) coarse sandy loam; weak, fine and very fine, subangular blocky structure; clay bridging; friable and slightly sticky; slightly acid; clear, wavy boundary.

B3—16 to 22 inches, dark-brown (10YR 3/3) stones and cobblestones imbedded in loamy coarse sand and coarse sandy loam; slightly sticky; massive; slightly acid; clear, wavy boundary.

C1—22 to 32 inches, dark-brown (10YR 4/3) and dark grayish-brown (10YR 4/2) coarse sand, gravel, stones, and cobblestones; single grain; loose; slightly calcareous; clear, wavy boundary; tongues of dark-brown (10YR 4/3) loamy coarse sand between stones in places.

C2—32 to 40 inches, variegated dark grayish-brown (10YR 4/2), dark-brown (10YR 4/3), grayish-brown (10YR 5/2) and brown (10YR 5/3) coarse sand, fine gravel, stones, and cobblestones; single grain; loose; calcareous.

In undisturbed areas the A1 horizon is 2 to 4 inches thick. It is typically sandy loam, but in spots it is loam. The A2 horizon is 1 to 3 inches thick. It has weak, thin, platy structure to weak, fine, granular structure. In cultivated areas the plow layer is generally very dark grayish-brown sandy loam. The B horizon has a higher clay content than the A horizon. It ranges from sandy loam to loam in texture. This horizon has weak to moderate, very fine and fine, blocky structure. In places the blocks have clay films and coatings of silica flour. The A and B horizons are slightly acid or medium acid. The limy, coarse underlying material is at a depth of 12 to 24 inches. In many places there are large stones and boulders on the surface and throughout the profile.

Burnsville soils are closely associated with the deep, well-drained Hayden soils, which developed in loam or clay loam glacial till. They have a thinner, lighter colored surface layer and a somewhat more clayey and structurally better developed subsoil than corresponding layers in the Estherville soils. They are also generally more acid.

Burnsville-Hayden complex, 2 to 6 percent slopes (BhB).—This complex is about 55 percent Burnsville sandy loam and loam, 25 percent Hayden sandy loam, and 20 percent Hayden loam. These soils have gently rolling, short, irregular slopes. Most of the acreage is only slightly eroded, but the intensively cropped areas have lost one-third to two-thirds of the original surface layer. In these areas the plow layer is a mixture of the original grayish-brown surface layer and yellowish-brown material from the subsoil. Included in mapping were a few spots where the surface is covered with sand and gravel.

These soils are fairly good for crops and are good for pasture. Droughtiness is a moderate to severe limitation. Erosion is a hazard. (Capability unit IIIe–5; woodland group 4; building site group 4)

Burnsville-Hayden complex, 6 to 12 percent slopes (BhC).—This complex is about 60 percent Burnsville sandy loam and loam, 25 percent Hayden sandy loam, and 15 percent Hayden loam. These soils have rolling, short, irregular slopes. Erosion has removed one-third to two-thirds of the original surface layer in cultivated areas but has been slight in pastured and wooded areas. In cultivated areas the plow layer is a mixture of the original grayish-brown surface layer and yellowish-brown material from the subsoil. Included in mapping were a few spots where the surface is covered with sand and gravel.

These soils are fair for small grain and pasture. They are too droughty to be suitable for corn. Crops make little growth during prolonged dry periods. The erosion hazard is severe. (Capability unit IVe–3; woodland group 4; building site group 5)

Burnsville-Hayden sandy loams, 12 to 18 percent slopes (BuD).—This unit is about 70 percent Burnsville sandy loam and 30 percent Hayden sandy loam. These soils have strongly rolling to moderately steep, short, irregular slopes. Erosion has removed one-third to two-thirds of the original surface layer in cultivated areas but has been slight in pastured and wooded areas. In cultivated areas the plow layer is a mixture of the original grayish-brown surface layer and yellowish-brown material from the subsoil. Included in mapping were spots where the surface is covered with sand and gravel. There are a few small gullies.

These soils are unsuitable for cultivated crops. Droughtiness is a limitation. The erosion hazard is very severe. (Capability unit VIe–2; woodland group 5; building site group 6)

Burnsville-Hayden sandy loams, 18 to 25 percent slopes (BuE).—This unit is about 75 percent Burnsville sandy loam and 25 percent Hayden sandy loam. The soils are steep and hilly. Erosion has removed one-third to two-thirds of the original surface layer in cultivated areas but has been slight in pastured and wooded areas. The plow layer in cultivated areas is a mixture of the original grayish-brown surface layer and yellowish-brown material from the subsoil. Included in mapping were spots where the surface is covered with sand and gravel.

These soils are so shallow and steep that droughtiness and erosion are very serious hazards. They are suited only to permanent vegetation. (Capability unit VIIe–2; woodland group 5; building site group 7)

Canisteo Series

The Canisteo series consists of deep, poorly drained soils that formed in friable, limy glacial till. These soils occupy flats and slightly elevated, irregular rims around depressions. The native vegetation was grass. Most of the acreage in this county is in the southwestern part.

The surface layer is black, friable silty clay loam. It is about 11 inches thick and has moderate, fine, granular structure. This layer contains a few fine snail shells and is limy. The subsurface layer is about 9 inches thick. It is black, limy silty clay loam. It is less friable than the surface layer and has weak to moderate blocky structure.

The subsoil is about 10 inches thick. It is very dark gray, massive, friable to firm, limy silty clay loam. The upper part is faintly mottled. The lower part is distinctly mottled with olive gray and dark gray.

The underlying material is olive-gray and gray silty clay loam glacial till that has faint olive mottles and a few reddish-orange iron stains. It is friable, limy, and massive.

Natural fertility is high. The organic-matter content is high. Runoff is slow, permeability is moderately slow, and the moisture-storage capacity is high. The water table is seasonally fairly high.

Drained areas are suited to all of the common crops. Most of the acreage is cultivated. Part of it is pastured.

Typical profile of Canisteo silty clay loam (meadow; 1 to 2 percent slope; SW¼SW¼ sec. 2, T. 116 N., R. 26 W.):

Ap—0 to 8 inches, black (N 2/0) silty clay loam; moderate, fine, granular structure; friable when moist, plastic and slightly sticky when wet; high organic-matter content; few fine snail shells; calcareous; abrupt, smooth boundary.

A1—8 to 11 inches, black (N 2/0) silty clay loam; moderate, fine, granular structure; friable when moist, plastic and slightly sticky when wet; few fine snail shells; calcareous; clear, wavy boundary.

A3—11 to 20 inches, black (10YR 2/1) silty clay loam; weak to moderate, very fine, subangular blocky structure; friable to firm when moist, plastic and slightly sticky when wet; calcareous; clear, wavy boundary.

B1g—20 to 24 inches, very dark gray (10YR 3/1) silty clay loam; few, fine, faint, very dark gray (5Y 3/1) and dark gray (5Y 4/1) mottles; massive; friable to firm when moist, plastic and slightly sticky when wet; calcareous; clear, wavy boundary.

B2g—24 to 30 inches, very dark gray (5Y 3/1) silty clay loam; common, fine, distinct, olive-gray (5Y 4/2) and dark-gray (5Y 4/1) mottles; massive; friable to firm when moist, plastic and slightly sticky when wet; calcareous; clear, wavy boundary.

C1g—30 to 36 inches, olive (5Y 4/3 and 5/3), olive-gray (5Y 4/2 and 5/2), and dark-gray (5Y 4/1) silty clay loam; massive; friable when moist, plastic and sticky when wet; calcareous; clear, wavy boundary.

C2g—36 to 50 inches, olive-gray (5Y 5/2) and gray (5Y 5/1) silty clay loam; few, fine, faint, olive (5Y 5/3) mottles; massive; friable when moist, plastic and slightly sticky when wet; few reddish-orange iron stains; calcareous.

The Ap horizon is typically silty clay loam, but in spots it is silt loam or clay loam. In some areas, because of the high lime content, it has a distinct light-grayish cast when dry. Ordinarily Canisteo soils are calcareous throughout the solum. The underlying material ranges from silty clay loam to clay loam and shows no marked increase in clay content. In places there are a few snail shells on the surface.

In comparison with the poorly drained Webster soils, Canisteo soils are limy throughout the profile. They are closely associated with the very poorly drained Glencoe soils, which are in depressions. Canisteo soils are finer textured throughout the solum than the poorly drained Mayer soils, which are underlain by sand and gravel.

Canisteo silty clay loam (Ca).—This soil occupies flats and slightly elevated rims around the Glencoe and Peat soils, which are in depressions. In some areas it has a distinct light-grayish cast when dry. Included in mapping were spots where the surface soil is strongly limy.

This soil is very good for crops and pasture. The content of lime is a minor limitation that can be offset by applying large amounts of potash and phosphate. Wetness is the major limitation. (Capability unit IIw–1; woodland group 8; building site group 9)

Canisteo silty clay loam, depressional (Cd).—This soil occupies wet depressions and drainageways in the uplands. It has a thicker, darker colored surface layer than Canisteo silty clay loam and is more frequently ponded. In places the surface is covered with a mantle, as much as 12 inches thick, of limy peat or muck. Generally the upper part of the soil contains fragments of snail shells.

Drained areas are good for corn and soybeans. The content of lime is a limitation that can be offset by applying large amounts of potash and phosphate. Undrained areas are used for wild hay and pasture. The marsh vegetation provides ideal cover for wildlife. Excess water is a serious limitation. This soil is more susceptible to frost than soils in higher lying positions. (Capability unit IIIw–1; woodland group 9; building site group 10)

Chaska Series

The Chaska series consists of silty soils on flood plains. These soils occur as fairly extensive areas along the Minnesota River. They are deep, nearly level, and poorly drained. The frequency of flooding is extremely variable. The native vegetation consisted of wetland grasses and sedges.

The surface layer is very dark gray, friable silty clay loam to loam. It is about 36 inches thick. The plow layer is cloddy. Below the plow layer the structure is weak to very weak blocky. It contains a few fine fragments of snail shells and is limy.

The underlying material is dark-gray to dark grayish-brown, massive, friable loam that has dark-brown mottles. This material also contains a few fine fragments of snail shells and is limy.

Natural fertility is high. The organic-matter content is high. Runoff is slow, permeability is moderate, and the moisture-storage capacity is high. The water table is seasonally high.

Chaska soils are used for crops and pasture. Flooding delays planting in spring and occasionally destroys crops in June.

Typical profile of Chaska silty clay loam (cultivated field; 1 percent slope; NE¼NE¼ sec. 12, T. 114 N., R. 24 W.):

Ap—0 to 8 inches, very dark gray (10YR 3/1) silty clay loam; dark gray (10YR 4/1) when dry; cloddy; friable; few fine remnants of snail shells; calcareous; abrupt, wavy boundary.

A11—8 to 17 inches, very dark gray (10YR 3/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, very fine, subangular blocky structure; friable; few fine remnants of snail shells; calcareous; gradual, wavy boundary.

A12—17 to 22 inches, very dark gray (10YR 3/1) silty clay loam; very weak, fine, subangular blocky structure; friable; few fine remnants of snail shells; calcareous; gradual, wavy boundary.

A13—22 to 36 inches, very dark gray (10YR 3/1) loam grading to very dark grayish brown (10YR 3/2); very weak, fine, subangular blocky structure; friable; few fine remnants of snail shells; calcareous; gradual, wavy boundary.

C—36 to 50 inches, dark-gray (10YR 4/1) loam grading to dark grayish brown (10YR 4/2); high in content of fine sand; few, fine, distinct, dark-brown (7.5YR 3/2) mottles; massive; friable; few fine remnants of snail shells; calcareous.

The Ap horizon is typically silty clay loam, but in spots it is silt loam or loam. It is very dark gray (10YR 3/1) but dries to dark gray (10YR 4/1) or gray (10YR 5/1). Ordinarily the solum contains remnants of snail shells and is calcareous. The lowermost part, from a depth of 24 to more than 40 inches, is generally mottled with dark gray or dark grayish brown. The underlying material ranges from loam or silt loam to silty clay loam and in places has discontinuous seams of fine sand or loamy fine sand.

Chaska soils are closely associated with the very poorly drained Oshawa soils, which occupy backwater sloughs and oxbows of the flood plain. In comparison with these soils, Chaska soils are not so distinctly mottled and are less frequently ponded. Chaska soils are lighter colored and more calcareous in the A horizon than the poorly drained Comfrey soils.

Chaska silty clay loam (Ch).—This soil is on the flood plain of the Minnesota River and is subject to flooding. In some areas it is dissected by meandering old stream channels. Consequently, fields in these areas are odd shaped and are difficult to work.

If drained and otherwise well managed, this soil is suited to corn and soybeans. It is also very good for small grain and pasture. Wetness and susceptibility to flooding are the major limitations. (Capability unit IIw–1; woodland group 8; building site group 11)

Comfrey Series

The Comfrey series consists of silty soils on flood plains. These soils are deep, nearly level, and poorly drained and are subject to flooding. The native vegetation consisted of wetland grasses and sedges. These soils occur along Bevens Creek and South Fork Crow River.

The surface layer is black, friable silty clay loam. It is slightly acid and is about 21 inches thick. The plow layer is cloddy. The rest has weak to moderate blocky structure. The subsurface layer is about 4 inches thick. It is friable, limy silty clay loam that has weak blocky structure. It is lighter colored than the surface soil.

The underlying material is friable, massive, limy silty clay loam. It is dark gray and grades to olive gray with increasing depth. It has olive mottles and thin, very dark brown seams of organic matter or iron.

Natural fertility is high. The organic-matter content is high. Runoff is slow, permeability is moderately slow, and the moisture-storage capacity is high. The water table is fairly high.

If protected from flooding and adequately drained, these soils are suited to all of the common crops, especially corn and soybeans. The acreage that is frequently flooded is used mainly for pasture or wild hay.

Typical profile of Comfrey silty clay loam (cultivated field; 1 percent slope; SW¼SW¼ sec. 6, T. 116 N., R. 26 W.):

Ap—0 to 9 inches, black (N 2/0) silty clay loam; cloddy; friable when moist, slightly plastic when wet; slightly acid; clear, smooth boundary.

A11—9 to 15 inches, black (N 2/0) silty clay loam; weak, very fine, subangular blocky structure; friable when moist, slightly plastic when wet; slightly acid; gradual, wavy boundary.

A12—15 to 21 inches, black (10YR 2/1) silty clay loam; weak to moderate, very fine, subangular blocky structure; friable when moist, plastic and slightly sticky when wet; slightly acid; gradual, wavy boundary.

A3—21 to 25 inches, very dark gray (10YR 3/1) silty clay loam; black (10YR 2/1) seams or streaks; weak, very fine, subangular blocky structure; friable when moist, plastic and slightly sticky when wet; calcareous; gradual, wavy boundary.

C1g—25 to 30 inches, dark-gray (5Y 4/1) silty clay loam; very thin seams of very dark brown (10YR 2/2) organic matter or iron; streaks of very dark gray (10YR 3/1); massive; friable when moist, plastic and slightly sticky when wet; calcareous; gradual, wavy boundary.

C2g—30 to 36 inches, dark-gray (5Y 4/1) silty clay loam; many, fine, faint, olive-gray (5Y 4/2) mottles; very thin seams of very dark brown (10YR 2/2) organic matter or iron; streaks of very dark gray (10YR 3/1); massive; friable when moist, plastic and sticky when wet; calcareous; gradual, wavy boundary.

C3g—36 to 48 inches, olive-gray (5Y 4/2) silty clay loam; many, fine, faint, olive (5Y 4/3) mottles; thin seams of very dark brown (10YR 2/2) iron or organic matter; streaks of olive gray (5Y 5/2); massive; friable when moist, plastic and sticky when wet; calcareous.

The Ap horizon is typically silty clay loam, but in spots it is silt loam. The underlying material also is typically silty clay loam but ranges to silt loam and clay loam. These soils are slightly acid to mildly alkaline and are typically limy within a depth of 42 inches.

Comfrey soils have a thicker surface layer than the poorly drained Webster soils, and formed in limy alluvium instead of glacial till. They are darker colored than the poorly drained Chaska soils.

Comfrey silty clay loam (Cm).—This soil is on flood plains. In some areas it is dissected by meandering old stream channels, and fields in these areas are odd shaped and difficult to work. Included in mapping were spots where the surface soil is limy.

If drained and otherwise well managed, this soil is suited to corn and soybeans and is very good for small grain and pasture. Wetness and the hazard of flooding are the major limitations. In most years floodwater recedes early enough to permit cropping. Occasionally, floods destroy crops in June. (Capability unit IIw–1; woodland group 8; building site group 11)

Comfrey silty clay loam, frequently flooded (Co).—This soil is on flood plains. Included in mapping were spots where the surface soil is limy. Also included were old stream channels, some of which are ponded throughout the year and are covered with a few inches of fibrous peat or muck.

This soil is not suitable for crops unless it is protected from flooding and then drained. Most of the acreage is used for pasture or wild hay. (Capability unit VIw–1; woodland group 9; building site group 11)

Cordova Series

The Cordova series consists of deep, poorly drained soils that formed in friable, limy glacial till. The original vegetation consisted of grasses on which mixed hardwoods encroached. These soils occupy flats and drainageways in the uplands.

The surface layer is black, friable silty clay loam. It is about 7 inches thick, has moderate blocky structure, and is slightly acid.

The subsoil, about 17 inches thick, is very dark gray silty clay loam that grades to olive-gray and olive, firm silty clay or heavy silty clay loam. It has moderate to strong structure and dark-colored clay and organic coatings. The upper part is medium acid, and the lower part is slightly acid.

The underlying material is olive-gray silty clay loam. It is friable, limy, and massive. This material grades to gray and olive-gray clay loam glacial till that has olive mottles and reddish-orange iron stains.

Figure 7 shows a typical profile of Cordova silty clay loam.

Natural fertility is high, and the organic-matter content is high. Runoff is slow, permeability is moderately slow, and the moisture-storage capacity is high. The water table is seasonally fairly high.

Drained areas are excellent for crops, especially corn and soybeans. Undrained areas are used mainly for pasture.

Typical profile of Cordova silty clay loam (wooded pasture; 1 percent slope; SE¼NE¼ sec. 6, T. 114 N., R. 24 W.):

A1—0 to 7 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure; friable when moist, slightly plastic and slightly sticky when wet; abundant roots; high organic-matter content; slightly acid; clear, smooth boundary.

AB—7 to 9 inches, very dark gray (10YR 3/1) silty clay loam; small pockets of light gray (10YR 6/1, dry); weak, very fine, subangular blocky structure; light-gray (10YR 6/1, dry), dusty silica coatings; friable when moist, slightly plastic when wet; abundant roots; medium acid; clear, smooth boundary.

Figure 7.—**Typical profile of Cordova silty clay loam.**

B21g—9 to 12 inches, silty clay loam; very dark gray (10YR 3/1) exteriors and very dark brown (10YR 2/2) interiors; moderate, very fine, subangular blocky structure; very dark gray (10YR 3/1) organic coatings on peds; light-gray (10YR 6/1, dry), dusty silica coatings; continuous, distinct clay films on vertical ped faces and patches on horizontal ped faces; friable to firm when moist, plastic and slightly sticky when wet; few roots; medium acid; clear, smooth boundary.

B22g—12 to 19 inches, very dark gray (5Y 3/1) silty clay or heavy silty clay loam; few, fine, faint, dark olive-gray (5Y 3/2) mottles; moderate to strong, very fine, subangular blocky structure; continuous, distinct clay films on all ped faces; peds are completely and deeply coated with very dark gray (10YR 3/1) or black (10YR 2/1); firm when moist, plastic and sticky when wet; few roots; medium acid; clear, smooth boundary.

B23g—19 to 24 inches, olive-gray (5Y 4/2) and olive (5Y 4/3) silty clay or heavy silty clay loam; moderate, very fine, subangular blocky structure; continuous, distinct clay films on vertical ped faces and patches on horizontal ped faces; coats are very dark gray (10YR and 5Y 3/1) and are black (10YR 2/1) in old root channels; firm when moist, plastic and sticky when wet; few roots; slightly acid; abrupt, smooth boundary.

C1g—24 to 27 inches, olive-gray (5Y 5/2) silty clay loam; many, fine, faint, olive (5Y 5/3 and 4/3) mottles; black (10YR 2/1) in old root channels; firm to friable when moist, plastic and sticky when wet; calcareous; clear, smooth boundary.

C2g—27 to 34 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) clay loam; many, fine, distinct, olive (5Y 5/3 and 4/3) mottles and few, fine, prominent, olive (5Y 5/6) mottles; thin seams of gray (5Y 6/1) feathered lime; massive; friable when moist, slightly plastic and slightly sticky when wet; reddish-orange iron stains; a few lime pebbles and shale fragments; calcareous; clear, smooth boundary.

C3g—34 to 41 inches, olive (5Y 5/3) and pale-olive (5Y 6/3) clay loam; many, fine, prominent, olive (5Y 5/4 and 5/6) mottles; thin seams of gray (5Y 6/1) feathered lime; massive; friable when moist, slightly plastic and slightly sticky when wet; reddish-orange iron stains; a few lime pebbles and shale fragments; calcareous; clear, smooth boundary.

C4g—41 to 52 inches, variegated olive (5Y 5/3, 5/4, and 5/6) clay loam; thin seams of gray (5Y 6/1) and light-gray (5Y 7/1) feathered lime; massive; friable when moist, slightly plastic and slightly sticky when wet; reddish-orange iron stains; calcareous.

The A1 horizon is typically silty clay loam, but in spots it is silt loam. It is generally 7 to 10 inches thick but ranges from 6 to 12 inches. The AB horizon is typically less than 3 inches thick. In a few places it has platy structure. The B horizon ranges from heavy silty clay loam and clay loam to silty clay. It has moderate to strong blocky structure to prismatic structure and patchy to continuous clay and organic films. The A1 horizon is neutral or slightly acid. The B horizon is slightly acid to strongly acid. There are a few stones and boulders on the surface and throughout the profile, and varying numbers of shale fragments.

Cordova soils have a finer textured subsoil than the poorly drained Webster soils and are generally more acid. They are closely associated with these soils. Cordova soils are also closely associated with the moderately well drained LeSueur soils and the well-drained Lester soils.

Cordova silty clay loam (Cs).—Mapped with this soil were small areas of Glencoe soils, which are in depressions.

If adequately drained and otherwise well managed, this soil is suited to small grain and pasture and very well suited to corn and soybeans. (Capability unit IIw–1; woodland group 8; building site group 9)

Cordova and Webster silty clay loams (Cw).—The Webster soil in this unit is described under the heading "Webster Series." Cordova soils are the more extensive. Included in mapping were spots of Glencoe soils, which are in depressions.

If adequately drained and otherwise well managed, these soils are suited to small grain and pasture and well suited to corn and soybeans. (Capability unit IIw–1; woodland group 8; building site group 9)

Dakota Series

The Dakota series consists of loamy, nearly level to gently sloping, somewhat excessively drained soils that are moderately deep over noncalcareous sand. These soils occur on the outwash plains of the Minnesota River. The original vegetation consisted of grasses on which deciduous hardwoods encroached.

The surface layer is very dark brown to very dark gray, friable sandy loam. It is medium acid, is about 11 inches thick, and has weak granular structure. The subsurface layer is about 4 inches thick. It has weak blocky structure and is somewhat more brownish than the surface layer.

The subsoil is about 18 inches thick. It is very dark brown, friable loam in the uppermost part and grades to dark grayish-brown and dark yellowish-brown, friable loam that has weak blocky structure. The lowermost part

is dark-brown, friable sandy loam to loose fine sand. This layer is medium acid.

The underlying material is yellowish-brown, slightly acid fine sand.

These soils are easy to work. They warm up early in spring and dry out fairly rapidly after a rain. Natural fertility is moderate. The organic-matter content is moderate. Runoff is medium, permeability is moderately rapid, and the moisture-storage capacity is moderately low.

These soils are used for general farming. They are suitable for small grain but are too droughty to be suitable for corn.

In this county Dakota soils are mapped only with Rasset soils. For a description of the Rasset part of the following mapping units, refer to "Rasset Series."

Typical profile of Dakota sandy loam (cornfield; 1 percent slope; NW¼SW¼ sec. 6, T. 114 N., R 23 W.):

Ap—0 to 11 inches, very dark brown (10YR 2/2) to very dark gray (10YR 3/1) sandy loam; weak, fine, granular structure; very friable; medium acid.

A3—11 to 15 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) sandy loam; weak, very fine, subangular blocky structure; friable; medium acid.

B21—15 to 18 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable when moist, slightly sticky when wet; medium acid.

B22—18 to 21 inches, dark grayish-brown (10YR 4/2) loam; weak, fine, subangular blocky structure; friable when moist, slightly sticky to sticky when wet; medium acid.

B23—21 to 25 inches, dark yellowish-brown (10YR 4/4) loam; weak, fine, subangular blocky structure; friable when moist, slightly sticky to sticky when wet; medium acid.

B24—25 to 29 inches, dark-brown (7.5YR 4/4) sandy loam; massive; friable; medium acid.

B3—29 to 33 inches, dark-brown (7.5YR 4/4) fine sand; massive; clay bridging; loose; medium acid.

C—33 to 50 inches, yellowish-brown (10YR 5/4 to 5/6) fine sand; single grain; loose; slightly acid.

The A horizon ranges from 10 to 16 inches in thickness. In comparison with the A horizon, the B2 horizon shows a noticeable increase in clay content; it is typically sandy loam, loam, or light sandy clay loam in texture. The B3 horizon ranges from sandy loam to sand. The depth to fine sand or sand is typically 30 to 40 inches but ranges from 24 to 42 inches. The reaction is neutral to medium acid to a depth of more than 60 inches.

Dakota soils are more deeply leached of lime carbonates than the well-drained Wadena soils, and their subsoil shows a more noticeable increase in content of clay. Dakota soils are closely associated with the somewhat excessively drained Rasset soils. They are deeper over sand than the Rasset soils, and they lack the variable textural bands in the solum and substratum that are typical of these soils. Dakota soils and the somewhat excessively drained Hubbard sandy loams formed in similar noncalcareous sand, but the Dakota soils are deeper over sand and their subsoil shows a more noticeable increase in content of clay.

Dakota and Rasset sandy loams, 0 to 2 percent slopes (DrA).—The profile of the Rasset soil in this unit differs from that described under the heading "Rasset Series" in having a surface layer of sandy loam instead of loamy sand. The Dakota soil is the more extensive. Generally the depth to sand is 30 to 36 inches.

These soils are good for small grain and pasture and fairly good for corn. Wind erosion is a hazard. (Capability unit IIIs–1; woodland group 4; building site group 1)

Dakota and Rasset sandy loams, 2 to 6 percent slopes (DrB).—These soils have gently undulating, short, smooth slopes. The profile of the Rasset soil differs from that described as typical of the series in having a surface layer of sandy loam instead of loamy sand. The Dakota soil is the more extensive. Generally the depth to sand is 24 to 30 inches.

These soils are moderately good for small grain and pasture. Droughtiness and the hazard of erosion are the main limitations. (Capability unit IIIe–4; woodland group 4; building site group 1)

Estherville Series

The Estherville series consists of loamy, nearly level to hilly, somewhat excessively drained soils that are shallow over limy sand and gravel. These soils are on outwash plains and terraces.

The surface layer is black, very friable sandy loam. It is about 10 inches thick, has weak to moderate granular structure, and is slightly acid.

The upper 8 inches of the subsoil is friable, dark-brown loam. The lower 3 inches is dark yellowish-brown coarse sandy loam. The subsoil is neutral and either has weak blocky structure or is massive.

The underlying material consists of stratified dark-brown and yellowish-brown, limy gravel and coarse sand.

Figure 8 shows a typical profile of Estherville sandy loam.

These soils are easy to work. They warm up early in spring and dry out rapidly after a rain. Natural fertility is moderately low. The organic-matter content is mod-

Figure 8.—**Typical profile of Estherville sandy loam.**

erate. Runoff is medium, internal drainage is rapid, and the moisture-storage capacity is low. Air and water move easily through the soil. The root zone is limited.

These soils are used for general farming. They are suitable for small grain but are too droughty to be suitable for corn.

Typical profile of Estherville sandy loam (alfalfa field; 1 percent slope; SE¼SE¼ sec. 17, T. 116 N., R. 26 W.):

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; weak, fine, granular structure; very friable; slightly acid; abrupt, smooth boundary.

A1—7 to 10 inches, black (10YR 2/1) sandy loam; weak to moderate, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

B2—10 to 18 inches, dark-brown (10YR 3/3) loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B3—18 to 21 inches, dark yellowish-brown (10YR 3/4) coarse sandy loam; massive; very friable; neutral; clear, smooth boundary.

C—21 to 40 inches, variegated dark-brown (10YR 3/3 and 4/3) and dark yellowish-brown (10YR 3/4 and 4/4) gravel and coarse sand; single grain; loose; calcareous.

The A horizon is typically sandy loam but ranges to loam. Both the A and B horizons are neutral to medium acid. The depth to sand and gravel ranges from 10 to 24 inches. In places the upper part of the underlying material is leached of free lime carbonates. Typically, the underlying material is limy within a depth of 30 inches.

Estherville soils are coarser textured and shallower over sand and gravel than the well-drained Wadena soils. They are less sandy than the somewhat excessively drained Hubbard soils, which formed in deep, noncalcareous sand.

Estherville sandy loam, 0 to 2 percent slopes (EsA).—In a few areas the surface layer of this soil is loam. The depth to sand and gravel is generally 16 to 20 inches. Included in mapping was about 20 acres where the soils are silt loam in texture, are underlain by limestone within a depth of 12 to 24 inches, and have rock fragments on the surface. This area is in section 6 of the San Francisco Township.

This soil is good for small grain and fairly good for pasture. It is only fair for corn. It is droughty and is subject to wind erosion. (Capability unit IIIs–2; woodland group 4; building site group 1)

Estherville sandy loam, 2 to 6 percent slopes (EsB).—This soil has gently undulating slopes. In a few areas the surface layer is loam. The depth to sand and gravel is generally 16 to 20 inches.

This soil is good for small grain and fairly good for pasture. It is only fair for corn. Droughtiness and the hazard of erosion are severe limitations. (Capability unit IIIe–5; woodland group 4; building site group 1)

Estherville sandy loam, 2 to 6 percent slopes, eroded (EsB2).—This soil has undulating slopes. It has lost 3 to 6 inches of its original surface layer through erosion. The present plow layer is a grayish-brown mixture of the original surface layer and material from the subsoil. The organic-matter content is generally low. The depth to sand and gravel is generally 14 to 16 inches. In spots the surface is covered with gravel.

This soil is fairly good for small grain and pasture but only fair for corn. Droughtiness and the risk of erosion are severe limitations. (Capability unit IIIe–5; woodland group 4; building site group 1)

Estherville sandy loam, 6 to 12 percent slopes (EsC).—This soil has rolling, short, irregular slopes. In a few areas the surface layer is loam. Most of the acreage is pastured or wooded and is only slightly eroded. The depth to gravel and sand is generally 15 to 18 inches.

This soil is fairly good for small grain and pasture. It is only fair to poor for corn because of droughtiness and the risk of erosion. (Capability unit IVe–3; woodland group 4; building site group 2)

Estherville sandy loam, 6 to 12 percent slopes, eroded (EsC2).—This soil has rolling, short, uneven slopes. It has lost 3 to 6 inches of its original surface layer through erosion. The present plow layer is grayish-brown sandy loam, which is a mixture of the original surface layer and material from the subsoil. The organic-matter content is generally low. The depth to sand and gravel is generally 14 to 16 inches. There are a few spots where the surface is covered with gravel. In a few areas there are gullies of varying sizes.

This soil is fair for small grain and pasture but poor for corn. It is droughty, and the risk of further erosion is very severe. (Capability unit IVe–3; woodland group 4; building site group 2)

Estherville sandy loam, 12 to 18 percent slopes (EsD).—This soil has short, irregular slopes. Erosion has removed as much as 6 inches of the original surface layer in most cultivated areas but has been slight in pastured or wooded areas. Most of the eroded soils have a plow layer of brownish sandy loam that is low in organic-matter content. The depth to sand and gravel ranges from 12 to 18 inches. In cultivated areas there are spots where the surface is covered with gravel. In places there are gullies of varying sizes.

This soil is unsuitable for crops and is only fair for pasture. It is droughty, and the erosion hazard is very severe. (Capability unit VIe–2; woodland group 5; building site group 3)

Estherville sandy loam, 18 to 25 percent slopes (EsE).—This soil is hilly. Erosion has removed as much as 6 inches of the original surface layer in most cultivated areas but has been slight in pastured or wooded areas. In eroded areas the plow layer is brownish sandy loam that is low in organic-matter content. The depth to sand and gravel is 12 to 18 inches.

Droughtiness and the hazard of erosion are very serious limitations. (Capability unit VIIe–2; woodland group 5; building site group 3)

Fairhaven Series, Deep Variant

The Fairhaven series, deep variant, consists of silty, well-drained, nearly level to gently sloping soils that are deep over limy sand. These soils occur on outwash plains along the Minnesota River. The original vegetation was prairie grass.

The surface layer is very dark gray, friable, slightly acid silt loam. It is about 10 inches thick. The plow layer is cloddy. The lower part has moderate blocky structure.

The subsoil is about 37 inches thick. The uppermost part is very dark brown silt loam that grades to dark grayish brown. It is friable, is slightly acid, and has weak blocky structure. The middle part is silty clay loam. It is dark brown and grades to dark yellowish brown. It is friable, is medium acid, and has weak blocky structure. The lowermost part is olive-brown silt loam that grades to light olive-brown very fine sandy loam. It is very friable, medium acid, and massive.

The underlying material is grayish and brownish very fine sand. It is medium acid in the upper part but limy at a depth of 52 inches.

Natural fertility is moderately high. The organic-matter content is high. Runoff is medium, permeability is moderate to moderately rapid, and the moisture-storage capacity is moderately high.

These soils are well suited to all of the common crops. Corn and soybeans are the main crops. Most of the acreage is cultivated.

Typical profile of Fairhaven silt loam, deep variant (cultivated field; 1 percent slope; NW¼NW¼ sec. 29, T. 114 N., R. 24 W.):

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam; cloddy; friable when moist, slightly plastic when wet; slightly acid; abrupt, smooth boundary.

A1—8 to 10 inches, very dark gray (10YR 3/1) silt loam; moderate, very fine, subangular blocky structure; friable when moist, slightly plastic when wet; slightly acid; clear, smooth boundary.

B1—10 to 15 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, subangular blocky structure; friable when moist, slightly plastic when wet; slightly acid; clear, smooth boundary.

B21—15 to 20 inches, dark grayish-brown (10YR 4/2) silt loam; weak, fine, subangular blocky structure; friable when moist, slightly plastic to plastic when wet; slightly acid; clear, smooth boundary.

B22—20 to 25 inches, dark-brown (10YR 4/3) silty clay loam; weak, fine, subangular blocky structure; friable when moist, slightly plastic to plastic when wet; slightly acid; clear, smooth boundary.

B23—25 to 34 inches, dark-brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) silty clay loam; weak, fine, subangular blocky structure; friable when moist, slightly plastic to plastic when wet; medium acid; clear, smooth boundary.

B24—34 to 42 inches, olive-brown (2.5Y 4/4) silt loam; massive; very friable when moist, nonplastic and slightly sticky when wet; medium acid; clear, smooth boundary.

B3—42 to 47 inches, light olive-brown (2.5Y 5/4) very fine sandy loam; massive; very friable when moist; medium acid; clear, smooth boundary.

C1—47 to 54 inches, pale-brown (10YR 6/3) and light brownish-gray (10YR 6/2) very fine sand; single grain; loose; medium acid; clear, smooth boundary.

C2—54 to 60 inches, variegated pale-brown (10YR 6/3), light olive-brown (2.5Y 5/4), light yellowish-brown (2.5Y 6/4), and light brownish-gray (2.5Y 6/2) very fine sand; single grain; loose; calcareous.

The A horizon is typically silt loam, but in spots it is silty clay loam. It ranges from 8 to 12 inches in thickness. The B1 horizon and most of the B2 horizon are silt loam or silty clay loam. In comparison with the A horizon, they show no marked increase in clay content. The B3 horizon ranges from silt loam to loamy very fine sand. The depth to fine sand and very fine sand ranges from 42 to 48 inches. The A horizon is neutral or slightly acid. The B horizon is neutral to medium acid. In places the upper part of the sandy underlying material is leached of lime carbonates. Typically, the underlying material is limy within a depth of 60 inches.

These soils are deeper over sand and are less droughty than the well-drained Fairhaven soils, sand substratum. They are deeper over sand and are more silty than either the well-drained Kasota soils, which have a clayey subsoil, or the well-drained Wadena soils, which are loamy throughout the profile.

Fairhaven silt loam, deep variant, 0 to 3 percent slopes (FhA).—In a few areas the surface layer of this soil is silty clay loam. The depth to fine sand ranges from 42 to 48 inches.

This soil is very good for cultivated crops and pasture or hay. (Capability unit I–1; woodland group 1; building site group 1)

Fairhaven Series, Sand Substratum

The Fairhaven series, sand substratum, consists of silty, well-drained, nearly level to rolling soils that are moderately deep over limy sand. These soils are on outwash plains along the Minnesota River. The original vegetation consisted of prairie grasses on which hardwoods, mainly maple, encroached.

The surface layer is very dark gray, friable silt loam. It is slightly acid and is about 7 inches thick. It is cloddy in cultivated areas.

The subsoil is slightly acid and is about 24 inches thick. The uppermost part is dark grayish-brown, friable silt loam that has weak blocky structure. The middle part is dark-brown to dark grayish-brown, friable silty clay loam that has moderate to weak blocky structure. The lowermost part is dark grayish-brown, friable, massive sandy clay loam.

The deep, limy underlying material is variegated grayish-brown and yellowish loose sand.

These soils warm up early in spring and dry out fairly rapidly after a rain. Natural fertility is moderately high. The organic-matter content is moderately high. Runoff is medium, permeability is moderately rapid, and the moisture-storage capacity is moderate.

These soils are used for general farming. They are slightly droughty, but they are suited to all of the common crops.

Typical profile of Fairhaven silt loam, sand substratum (cornfield; 1 percent slope; SW¼SW¼ sec. 24, T. 115 N., R. 24 W.):

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam; cloddy; friable when moist, slightly plastic when wet; slightly acid; abrupt, smooth boundary.

B1—7 to 10 inches, dark grayish-brown (10YR 4/2) silt loam; exterior coats of very dark brown (10YR 2/2); weak, very fine and fine, subangular blocky structure; weathered peds; friable when moist, slightly plastic when wet; slightly acid; clear, smooth boundary.

B21—10 to 14 inches, dark-brown (10YR 4/3) silty clay loam; coats and deep penetrations of very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2); moderate, very fine, subangular blocky structure; friable when moist, plastic when wet; slightly acid; clear, smooth boundary.

B22—14 to 20 inches, dark-brown (10YR 4/3) silty clay loam; few penetrations of very dark grayish brown (10YR 3/2) in old root channels; weak, fine and very fine, subangular blocky structure; friable when moist, plastic when wet; slightly acid; clear, smooth boundary.

B23—20 to 28 inches, dark grayish-brown (10YR 4/2) silty clay loam or silt loam; massive; friable when moist, plastic when wet; slightly acid; clear, smooth boundary.

B3—28 to 31 inches, dark grayish-brown (10YR 4/2) sandy clay loam or loam; massive; friable when moist, slightly sticky when wet; slightly acid; clear, smooth boundary.

C1—31 to 35 inches, variegated dark grayish-brown (10YR 4/2), dark-brown (10YR 4/3), and brown (10YR 5/3) sand; single grain; loose; slightly calcareous; clear, smooth boundary.

C2—35 to 52 inches, variegated grayish-brown (10YR 5/2), light brownish-gray (10YR 6/2), and light yellowish-brown (10YR 6/4) sand; single grain; loose; calcareous.

The Ap horizon is typically silt loam. In spots, however, it is very fine sandy loam or silty clay loam. It is black, very dark gray, or very dark brown and ranges from 7 to 10 inches in thickness. In a few undisturbed wooded areas, this horizon is underlain by a very thin, lighter colored horizon. The B1 and B2 horizons range from silt loam to silty clay loam. In comparison with the A horizon, they show little or no increase in clay content. The B3 horizon ranges from sandy clay loam to sandy loam. The depth to loose sand ranges from 24 to 42 inches. In some areas the underlying material consists of stratified sand, fine sand, and very coarse sand and gravel. The Ap horizon is neutral or slightly acid. The B horizon is neutral to medium acid. In places the upper part of the sandy underlying material is leached of lime carbonates, but the underlying material typically is limy within a depth of 42 inches.

These soils are shallower over sand than the well-drained Fairhaven soils, deep variant. They are more silty than either the well-drained Kasota soils, which have a clayey subsoil, or the well-drained Wadena soils, which are loamy throughout the profile.

Fairhaven silt loam, sand substratum, 0 to 2 percent slopes (FaA).—In a few areas the surface layer of this soil is silty clay loam. The depth to sand generally is 24 to 36 inches.

This soil is slightly droughty, but it is good for crops and pasture. (Capability unit IIs–1; woodland group 1; building site group 1)

Fairhaven silt loam, sand substratum, 2 to 6 percent slopes (FaB).—This soil has gently undulating, fairly long, smooth slopes. In a few spots the surface layer is fine sandy loam. The depth to sand generally is 24 to 36 inches. Included in mapping were a few areas where erosion has removed 3 to 6 inches of the original surface layer. In these areas the plow layer is a brownish mixture of the original surface soil and material from the subsoil, and the organic-matter content is low. The depth to sand in these areas generally is 24 to 30 inches.

This soil is good for crops and pasture. Erosion is a hazard. Unless erosion is controlled, droughtiness is likely to become a serious limitation. (Capability unit IIe–4; woodland group 1; building site group 1)

Fairhaven silt loam, sand substratum, 6 to 12 percent slopes, eroded (FaC2).—This soil has rolling, fairly long, smooth slopes. Erosion has removed 3 to 6 inches of the original surface layer. The present plow layer is a brownish mixture of the original surface layer and material from the subsoil. The organic-matter content is generally low. In a few small areas the surface layer is fine sandy loam. Some moderately steep areas were included in mapping. The depth to sand is generally 24 to 30 inches.

This soil is fairly good for small grain and good for pasture. The erosion hazard is severe. Unless erosion is controlled, droughtiness is likely to become a serious limitation. (Capability unit IIIe–3; woodland group 2; building site group 2)

Glencoe Series

The Glencoe series consists of silty, deep, very poorly drained soils that formed in friable, limy glacial till. These soils occupy depressions and drainageways in the uplands. The native vegetation was marsh grass.

The surface is covered with a mantle of black, friable organic matter that is about 9 inches thick, has weak granular structure, and is slightly acid. The surface layer is black, friable silty clay loam. It is neutral, has moderate to weak blocky structure, and is about 15 inches thick. The subsurface layer is black to very dark gray, friable clay loam mottled with dark olive gray, olive gray, and gray. It is neutral, massive, and about 10 inches thick.

The subsoil, about 19 inches thick, is clay loam. It is olive, olive gray, and dark gray and contains many reddish-orange iron stains. This layer is friable, neutral, and massive.

The underlying material is friable clay loam glacial till mottled with olive, dark gray, gray, and olive gray. It is massive and limy.

Unless drained, these soils are periodically ponded. During prolonged wet periods, some areas are flooded the year around. Runoff is very slow, and the moisture-storage capacity is high. The movement of water in the soil is moderately slow. Natural fertility is high. The organic-matter content is high.

Drained areas are very good for corn and soybeans. Undrained areas are used mainly for wild hay and pasture.

Typical profile of Glencoe silty clay loam (marshy depression; less than 1 percent slope; NE¼SE¼ sec. 3, T. 116 N., R. 26 W.):

O2—0 to 9 inches, black (N 2/0) organic material; weak, fine, granular structure; friable; slightly acid.

A11—9 to 12 inches, black (N 2/0) silty clay loam; moderate, very fine, subangular blocky structure; friable when moist, slightly plastic when wet; neutral; gradual, wavy boundary.

A12—12 to 15 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable when moist, plastic when wet; neutral; gradual, wavy boundary.

A31g—15 to 20 inches, black (5Y 2/1) and very dark gray (5Y 3/1) clay loam; few, fine, faint, dark olive-gray (5Y 3/2) mottles; massive; friable when moist, slightly plastic and sticky when wet; a few reddish-orange iron stains; neutral; gradual, wavy boundary.

A32g—20 to 25 inches, very dark gray (5Y 3/1) and black (5Y 2/1) clay loam; few, fine, faint mottles of dark olive gray (5Y 3/2, olive gray (5Y 4/2), and olive (5Y 4/3); massive; friable when moist, slightly plastic and sticky when wet; many reddish-orange iron stains; a few lime pebbles; neutral; gradual, wavy boundary.

B1g—25 to 30 inches, olive-gray (5Y 4/2) and dark-gray (5Y 4/1) clay loam; massive; friable when moist, slightly plastic and sticky when wet; many reddish-orange iron stains; neutral; gradual, wavy boundary.

B2g—30 to 44 inches, olive (5Y 4/3 to 5/3 and 5/4) clay loam; massive; friable when moist, slightly plastic and sticky when wet; many reddish-orange iron stains; neutral; gradual, wavy boundary.

C1g—44 to 50 inches, variegated olive (5Y 5/3, 4/3, 5/4, and 4/4) clay loam; massive; friable when moist, slightly plastic and sticky when wet; many reddish-orange iron stains; slightly calcareous; gradual, wavy boundary.

C2g—50 to 54 inches, variegated dark-gray (5Y 4/1), gray (5Y 5/1), and olive-gray (5Y 5/2 and 4/2) clay loam; massive; friable when moist, slightly plastic and sticky when wet; many reddish-orange iron stains; calcareous.

The mantle of organic matter is lacking in some areas. The A1 horizon is typically silty clay loam, but in spots it is silt loam. The thickness of the A horizon generally is more than 24 inches. The B horizon and the underlying material range from silty clay loam to clay loam and have variable mottles and reddish-orange iron stains. The A horizon is neutral or slightly acid. Typically, the limy underlying material is within a depth of 48 inches.

Glencoe soils have a much thicker surface layer and a more abruptly and distinctly gleyed subsoil than the poorly drained Webster soils. Also, they are more likely to be ponded. They

differ from the very poorly drained Talcot soils, which are moderately deep over sand and gravel and are limy throughout the profile. They are not so limy as Canisteo silty clay loam, depressional, which is very poorly drained.

Glencoe silty clay loam (Ge).—This soil occupies depressions and drainageways.

Undrained areas are fair for wild hay or pasture and provide ideal cover for wildlife. Drained areas are good for corn and soybeans, but they are susceptible to frost. Excess water is a severe limitation. (Capability unit IIIw–1; woodland group 9; building site group 10)

Hayden Series

The Hayden series consists of deep, well-drained soils that formed in friable, limy clay loam or loam glacial till. These soils are extensive in this county. The slopes are undulating to steep, and the topography is morainic. The original vegetation consisted of deciduous hardwoods.

The surface layer is black, friable loam. It is about 2 inches thick, has moderate granular structure, and is slightly acid. The subsurface layer, about 7 inches thick, also is friable loam. This layer is medium acid. The upper part is very dark gray and has platy structure. The lower part is very dark grayish brown and has weak blocky structure.

The subsoil is about 25 inches thick and is medium acid. The uppermost part is dark-brown, friable loam that has moderate blocky structure and is medium acid. There are grayish, dusty, silica coatings on the blocks. The middle part is dark-brown, firm clay loam that has moderate blocky structure. This part grades to dark yellowish-brown and light olive-brown, firm to friable clay loam that has moderate prismatic structure. There are dark grayish-brown clay films and organic films on the blocks. The lowermost part is light olive-brown, massive clay loam that has very dark grayish-brown organic stains.

The underlying material is light olive-brown, friable loam glacial till. It is limy and massive. There are streaks of light brownish-gray lime, very dark grayish-brown organic stains, and a few reddish-orange iron stains.

Figure 9 shows a typical profile of Hayden loam.

Natural fertility is moderate. The organic-matter content is low. Runoff is medium to rapid, depending on the slope. Permeability is moderate, and the moisture-storage capacity is moderately high.

Most of the acreage is either cultivated or pastured. A few areas are wooded. The less sloping soils are suited to all of the common crops. The steeper soils are subject to severe erosion and are used mainly for hay and pasture.

Typical profile of Hayden loam (wooded pasture; 5 percent slope; NE¼NW¼ sec. 7, T. 116 N., R. 23 W.):

A1—0 to 2 inches, black (10YR 2/1) loam; moderate, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A21—2 to 6 inches, very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) when dry; weak, thin, platy structure; friable; medium acid; clear, smooth boundary.

A22—6 to 9 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; some remnants of old B1 horizon; medium acid; gradual, smooth boundary.

B1—9 to 15 inches, dark-brown (10YR 4/3) loam; moderate, very fine and fine, subangular blocky structure with degraded faces; dark grayish-brown (10YR 4/2) ped faces; light brownish-gray (10YR 6/2, dry) silica coatings; friable; medium acid; gradual, wavy boundary.

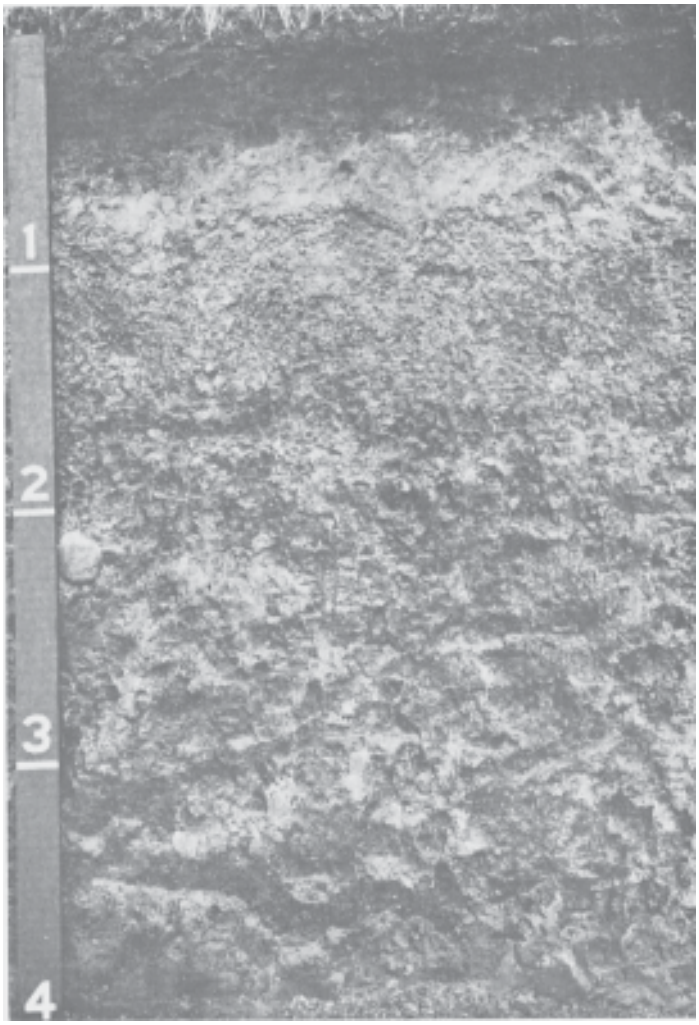


Figure 9.—**Typical profile of Hayden loam.**

B21—15 to 22 inches, dark-brown (10YR 4/3) clay loam; moderate, fine, subangular blocky structure; dark grayish-brown (10YR 4/2) ped faces; continuous, distinct clay films on all ped faces; firm; a few fine shale fragments; medium acid; clear, smooth boundary.

B22—22 to 27 inches, dark yellowish-brown (10YR 4/4) clay loam; moderate, fine, prismatic structure; dark grayish-brown (10YR 4/2) ped faces; continuous, distinct clay films on vertical ped faces and patches on horizontal ped faces; firm; medium acid; a few fine shale fragments; clear, smooth boundary.

B23—27 to 34 inches, light olive-brown (2.5Y 5/4 and 5/6) clay loam; moderate, medium and fine, prismatic structure; dark grayish-brown (10YR 4/2) ped faces; clay films on the faces of some peds and in old root channels; friable; medium acid; clear, smooth boundary.

B3—34 to 39 inches, light olive-brown (2.5Y 5/4) clay loam; heavily penetrated or infiltrated by very dark grayish-brown (10YR 3/2) organic stains; massive; friable; medium acid; clear, smooth boundary.

C1—39 to 44 inches, light olive-brown (2.5Y 5/4) loam; streaks of light brownish-gray (10YR 6/2) feathered lime and very dark grayish-brown (10YR 3/2) organic stains; massive; friable; a few reddish-orange iron stains; slightly calcareous; abrupt, smooth boundary.

C2—44 to 52 inches, light olive-brown (2.5Y 5/4) loam; streaks of light brownish-gray (10YR 6/2) feathered lime and very dark grayish-brown (10YR 3/2) organic stains; massive; friable; a few reddish-orange iron stains; calcareous.

The A horizon is typically loam. In places it is clay loam, and in spots sandy loam. In cultivated areas the Ap horizon is typically dark grayish brown and is about 7 inches thick. In undisturbed wooded and pastured areas, the A1 horizon is less than 4 inches thick. The A2 horizon is 2 to 10 inches thick and generally has platy structure. The B2 horizon is typically clay loam. It shows a marked increase in clay content in comparison with the surface layer and the underlying material. Clay films are generally continuous over the blocks in the more strongly developed part of the B horizon. The blocks in the uppermost part generally have coatings of silica flour that has filtered down from the A2 horizon. The very dark grayish-brown organic stains are pronounced in the B3 horizon and generally protrude into old root channels of the underlying material. Most of the B horizon has moderate to strong, blocky or prismatic structure. The A horizon is typically slightly acid. The B horizon is generally medium acid but ranges from slightly acid to strongly acid. The depth to limy clay loam or loam glacial till is typically 36 to 42 inches. There are a few stones and boulders on the surface and throughout the soil, and varying numbers of shale fragments.

Hayden soils and the well-drained Lester soils formed in similar material, but Hayden soils formed under deciduous hardwoods and Lester soils under prairie grasses and hardwoods. In comparison with Lester soils, Hayden soils have a thinner surface layer, a more distinct, grayish subsurface layer, a more strongly developed subsoil, and a greater increase in content of clay in the subsoil. Hayden soils are also associated with the moderately well drained LeSueur soils and the poorly drained Cordova soils, which occur on flats and slight rises.

Hayden clay loam, 6 to 12 percent slopes, severely eroded (HcC3).—This soil has lost nearly all of its original surface layer through erosion. The plow layer consists almost entirely of material from the subsoil. It is brownish clay loam, is very low in organic-matter content, and has poor tilth. Crusts form and make cultivation and preparation of a seedbed difficult. The loss of organic matter has slowed infiltration and decreased the moisture-storage capacity, and the soil is slightly droughty. The depth to limy material is generally about 30 inches. There are a few small gullies.

This soil is fair for crops and good for pasture. It should not be cultivated every year. The erosion hazard is very severe. (Capability unit IVe–1; woodland group 2; building site group 5)

Hayden clay loam, 12 to 18 percent slopes, severely eroded (HcD3).—This soil has lost nearly all of its original surface layer through erosion. The plow layer consists almost entirely of material from the subsoil. It is brownish clay loam, is very low in organic-matter content, and has poor tilth. A crust forms that makes cultivation difficult. The loss of organic matter has slowed infiltration and decreased the moisture-storage capacity, and the soil is slightly droughty. Typically, the depth to the limy underlying material is 24 to 36 inches. Bald spots of limy loam occur on the steeper slopes. Small depressions occupied by Glencoe and Webster soils occur in areas where slopes are complex. There are a few small gullies.

This soil is not suitable for cultivated crops. The erosion hazard is very severe. (Capability unit VIe–1; woodland group 2; building site group 6)

Hayden clay loam, 18 to 25 percent slopes, severely eroded (HcE3).—This soil has been tilled, and erosion has removed nearly all of the original surface layer. The present plow layer is mainly brownish clay loam that was originally part of the subsoil. It is very low in organic-matter content and consequently has poor tilth. Runoff is rapid. Preparing a seedbed and maintaining a cover of vegetation are difficult. The depth to limy material is 24 to 36 inches. Bald spots of limy clay loam occur in a few areas. Small depressions occupied by Glencoe and Webster soils occur in areas where slopes are complex. Some areas are gullied.

This soil is not suitable for cultivated crops. Erosion and steep slopes are severe limitations. (Capability unit VIIe–1; woodland group 3; building site group 7)

Hayden loam, 2 to 6 percent slopes (HaB).—This soil is gently sloping or undulating. Small depressions occupied by the moderately well drained LeSueur soils and the poorly drained Webster soils occur in areas where slopes are irregular.

This soil is very good for crops and pasture. Erosion is a moderate hazard. (Capability unit IIe–3; woodland group 1; building site group 4)

Hayden loam, 2 to 6 percent slopes, eroded (HaB2).—This soil has gently undulating slopes that range from short and irregular to fairly long and smooth. Erosion has removed 3 to 6 inches of the original surface layer. The plow layer is a mixture of the original dark grayish-brown surface layer and brownish, finer textured material from the subsoil. The organic-matter content is generally low. Poorly drained soils in depressions occur in areas where slopes are complex.

This soil is very good for crops and pasture. The erosion hazard is moderate. (Capability unit IIe–3; woodland group 1; building site group 4)

Hayden loam, 6 to 12 percent slopes (HaC).—This soil has rolling slopes that range from short and irregular to fairly long and smooth. Small depressions occupied by Glencoe and Webster soils occur in areas where slopes are complex.

This soil is good for crops and pasture. If cultivated, it is highly susceptible to erosion. Part of the acreage has been cleared recently. The rest is pastured or wooded. (Capability unit IIIe–2; woodland group 2; building site group 5)

Hayden loam, 6 to 12 percent slopes, eroded (HaC2).—This soil has lost 3 to 6 inches of its original surface layer through erosion. The present grayish-brown plow layer is a mixture of the original loam surface layer and finer textured material from the subsoil. Tilth is poor. A crust forms that slows infiltration. Depressions occupied by Glencoe and Webster soils occur in areas where slopes are irregular.

This soil is moderately good for crops and good for pasture. The erosion hazard is severe. Erosion-control measures are needed if this soil is cultivated. (Capability unit IIIe–2; woodland group 2; building site group 5)

Hayden loam, 12 to 18 percent slopes (HaD).—This soil has hilly or moderately steep slopes. Runoff is rapid, but the moisture-storage capacity is fairly high. The depth to limy material is generally 30 to 36 inches. Depressions occupied by Glencoe and Webster soils occur in areas where slopes are irregular.

This soil is fair for crops and is moderately good for pasture. The erosion hazard is severe. Most of the acreage is wooded or pastured. (Capability unit IVe–1; woodland group 2; building site group 6)

Hayden loam, 12 to 18 percent slopes, eroded (HaD2).—This soil has lost 3 to 6 inches of its original surface layer through erosion. The present plow layer is a mixture of the original dark grayish-brown surface layer and brownish, finer textured material from the subsoil. The depth to limy material is generally 24 to 36 inches. The organic-matter content is very low. Consequently, crusts form and tilth is poor. Runoff is rapid, and the moisture supply is generally inadequate for crops during prolonged dry periods. Depressions occupied by Glencoe and Webster soils occur in areas where slopes are irregular. Small gullies have formed in some areas.

This soil is fair for crops and moderately good for pasture. The erosion hazard is severe. (Capability unit IVe–1; woodland group 2; building site group 6)

Hayden loam, 18 to 25 percent slopes, eroded (HaE2).—In cultivated areas erosion has removed 3 to 6 inches of the original surface layer from this soil. The plow layer in these areas is a mixture of the original dark grayish-brown surface layer and brownish, finer textured material from the subsoil. Pastured and wooded areas are only slightly eroded. The depth to limy material is generally about 24 to 36 inches. Small depressions occupied by Glencoe and Webster soils occur in areas where slopes are complex.

This soil is generally unsuitable for tilled crops but, if well managed, is fairly good for hay or pasture. The erosion hazard is very severe. (Capability unit VIe–1; woodland group 3; building site group 7)

Hayden loam, 25 to 40 percent slopes (HaF).—This unit consists of steep hills, ridges, and ravines. In cultivated areas erosion has removed 3 to 6 inches of the original surface layer and exposed the brownish clay loam subsoil. The depth to limy material ranges from 24 to 36 inches. Runoff is rapid. Bald spots of limy clay loam occur in a few areas. Small depressions occupied by Glencoe and Webster soils occur in areas where slopes are complex.

This soil should never be tilled. The erosion hazard is very severe. Pasture grasses burn during prolonged dry periods. Most of the acreage is wooded or pastured. (Capability unit VIIe–1; woodland group 3; building site group 7)

Hubbard Series

The Hubbard series consists of nearly level to hilly, somewhat excessively drained and excessively drained soils that formed in deep, acid sand. These soils are inextensive in this county. They occur mainly on outwash plains and terraces along the Minnesota and Crow Rivers. The native vegetation was prairie grass.

The surface layer is very dark gray, very friable loamy sand. It is about 10 inches thick, has weak granular structure, and is slightly acid. The subsurface layer is very dark grayish-brown, very friable loamy sand. This layer is about 4 inches thick, has weak granular structure, and is slightly acid.

The subsoil is about 9 inches thick. The upper part is dark grayish-brown, very friable, slightly acid loamy sand that has weak granular structure. The lower part is dark-brown, loose, slightly acid sand.

The underlying material is yellowish-brown and dark-brown, loose, slightly acid sand.

These soils are easy to work. They warm up early in spring and dry out rapidly after a rain. Natural fertility is moderate to low. The organic-matter content is moderate. Runoff is medium, permeability is rapid, and the moisture-storage capacity is low to very low.

These soils are used for crops and pasture. They are suitable for small grain but are too droughty to be suitable for corn. Wind erosion is a hazard.

Typical profile of Hubbard loamy sand (alfalfa field; 2 percent slope; SW¼NE¼ sec. 11, T. 114 N., R. 24 W.):

Ap—0 to 10 inches, very dark gray (10YR 3/1) loamy sand; weak, fine, granular structure; very friable; slightly acid; abrupt, smooth boundary.

A3—10 to 14 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

B21—14 to 18 inches, dark grayish-brown (10YR 4/2) loamy sand; weak, fine, granular structure; very friable; slightly acid.

B22—18 to 23 inches, dark-brown (10YR 4/3) sand; single grain; loose; slightly acid; gradual, wavy boundary.

C—23 to 52 inches, yellowish-brown (10YR 5/4) and dark-brown (10YR 4/3) sand; single grain; loose; slightly acid.

The A horizon is either loamy sand or sandy loam. Where the A horizon is loamy sand, the B horizon is loamy sand or sand. Where the A horizon is sandy loam, the B horizon is sandy loam that grades to loamy sand. These soils are slightly acid or medium acid to a depth of more than 60 inches.

Hubbard soils are more deeply leached of free lime carbonates than the somewhat excessively drained Estherville soils, which are underlain by gravel. They are also more deeply leached than the well-drained Wadena soils and have a coarser textured profile.

Hubbard loamy sand, 0 to 2 percent slopes (HdA).—This soil has lost 3 to 6 inches of its original surface layer through wind erosion. The present plow layer is grayish-brown loamy sand. Generally, the organic-matter content is low. The depth to sand is about 10 to 14 inches.

This soil is fair for small grain and pasture, but it is too droughty to be suitable for corn. The very low moisture-storage capacity is a severe limitation. Controlling wind erosion (fig. 10) is a serious problem. (Capability unit IVs–1; woodland group 6; building site group 1)

Figure 10.—**Severe wind erosion on Hubbard loamy sand, 0 to 2 percent slopes.**

Hubbard loamy sand, 2 to 6 percent slopes (HdB).—This soil has undulating slopes. In some windswept areas, it has lost 3 to 6 inches of its original surface layer. The plow layer in these areas is grayish-brown loamy sand and is very low in organic-matter content. The depth to sand ranges from 10 to 16 inches.

This soil is fair for small grain and early pasture, but it is too droughty to be suitable for corn. The very low moisture-storage capacity is a severe limitation. Wind erosion is a hazard. (Capability unit IVs–1; woodland group 6; building site group 1)

Hubbard loamy sand, 6 to 12 percent slopes (HdC).—This soil has strong, generally short slopes. In most cropped areas erosion has removed 3 to 6 inches of the original surface layer. The plow layer is grayish-brown loamy sand that is very low in organic-matter content. The depth to sand ranges from 10 to 16 inches.

The very low moisture-storage capacity severely limits the use of this soil for crops and pasture. Erosion is difficult to control in tilled areas. (Capability unit VIs–1; woodland group 6; building site group 2)

Hubbard loamy sand, 12 to 18 percent slopes (HdD).—In pastured or wooded areas, this soil is only slightly eroded. In cropped areas it has lost as much as 6 inches of its original surface layer. The plow layer, which is dominantly subsoil material, is brownish loamy sand that is very low in organic-matter content. Generally the depth to sand is 10 to 14 inches.

This soil is unsuitable for crops. It ought to be in permanent vegetation. Droughtiness is a serious limitation, and the erosion hazard is severe. (Capability unit VIIs–1; woodland group 7; building site group 3)

Hubbard loamy sand, 18 to 35 percent slopes (HdF).—Practically the entire acreage of this soil is wooded or pastured and is only slightly eroded. Generally the depth to sand is 10 to 14 inches.

This soil is extremely droughty. The erosion hazard is severe. (Capability unit VIIs–1; woodland group 7; building site group 3)

Hubbard sandy loam, 0 to 2 percent slopes (HuA).—In a few areas wind erosion has been moderate and the surface layer is slightly thinner than is typical. Generally the organic-matter content is low. The depth to sand is typically 16 to 20 inches.

This soil is suitable for small grain and pasture grasses, but it is too droughty to be suitable for corn. Wind erosion is a hazard. (Capability unit IIIs–1; woodland group 4; building site group 1)

Hubbard sandy loam, 2 to 6 percent slopes, eroded (HuB2).—This soil has undulating slopes. It has lost 3 to 6 inches of its original surface layer through erosion. The present plow layer, which is a mixture of the original surface layer and material from the subsoil, is grayish-brown sandy loam that generally is low in organic-matter content. The depth to sand is typically 14 to 16 inches. Included in mapping were a few wooded or pastured areas that are only slightly eroded.

If the supply of moisture is adequate, this soil is moderately good for small grain and good for pasture. It is too droughty to be suitable for corn. Further erosion will make it more droughty. (Capability unit IIIe–4; woodland group 4; building site group 1)

Hubbard sandy loam, 6 to 12 percent slopes, eroded (HuC2).—This soil has lost 3 to 6 inches of its original surface layer through erosion. The present plow layer, which is a mixture of the original surface layer and material from the subsoil, is grayish-brown sandy loam that generally is low in organic-matter content. The depth to sand is typically 14 to 16 inches. Included in mapping were a few wooded or pastured areas that are only slightly eroded.

This soil is fairly good for small grain and early pasture, but it is too droughty to be suitable for corn. The erosion hazard is severe. (Capability unit IVe–2; woodland group 4; building site group 2)

Hubbard sandy loam, 12 to 18 percent slopes (HuD).—Most of this soil is wooded or pastured and is only slightly eroded. In cropped areas the soil has lost as much as 6 inches of its original surface layer and is low in organic-matter content. The depth to sand is 14 to 18 inches. In places there are thin loamy bands within a depth of 18 to 36 inches.

This soil is not suitable for crops. It is extremely droughty, and the erosion hazard is severe. (Capability unit VIe–2; woodland group 5; building site group 3)

Kasota Series

The Kasota series consists of loamy, nearly level to gently sloping, well-drained soils that have a clayey subsoil. These soils are moderately deep over sand and gravel. They are mainly on outwash plains of the Minnesota River. The original vegetation consisted of prairie grasses on which mixed hardwoods encroached.

The surface layer is very dark gray to very dark brown, friable loam. It is neutral and is about 6 inches thick. In cultivated areas it is cloddy. The subsurface layer is similar, but it is 2 inches thick and has weak blocky structure. It is somewhat lighter colored than the surface layer.

The subsoil is about 32 inches thick. The uppermost part is dark grayish-brown, friable to firm clay loam that has weak blocky structure. It is slightly acid. The middle part is dark-brown, firm to very firm clay or clay loam that has weak blocky structure. This part is medium acid. The lowermost part is brown, friable to firm clay loam that grades to yellowish and brownish sand and fine sand. It is medium acid or slightly acid.

The limy underlying material is brownish and grayish sand and coarse sand.

These soils tend to be deficient in moisture during long dry spells. Natural fertility is moderately high. The organic-matter content is moderately high. Runoff is medium, permeability is moderate to moderately slow, and the moisture-storage capacity is moderately high.

These soils are suited to all of the common crops.

Typical profile of Kasota loam (cultivated field; 1 percent slope; NE¼NE¼ sec. 1, T. 114 N., R. 24 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) to very dark brown (10YR 2/2) loam; cloddy; friable when moist, slightly plastic and slightly sticky when wet; neutral.

A3—6 to 8 inches, very dark grayish-brown (10YR 3/2) clay loam; weak, fine, subangular blocky structure; friable when moist, slightly plastic and slightly sticky when wet; neutral.

B1—8 to 11 inches, dark grayish-brown (10YR 4/2) clay loam; weak, very fine and fine, subangular blocky structure; friable to firm when moist, slightly plastic and slightly sticky when wet; slightly acid.

B21—11 to 16 inches, dark-brown (10YR 4/3) clay or clay loam; weak, fine, subangular blocky structure; firm when moist, plastic and sticky when wet; medium acid.

B22—16 to 23 inches, dark-brown (10YR 4/3) clay; weak, fine, subangular blocky structure; firm to very firm when moist, plastic and sticky when wet; medium acid.

B23—23 to 28 inches, brown (10YR 5/3) clay loam grading to loam; massive; firm to friable when moist, slightly plastic and slightly sticky when wet; medium acid.

B31—28 to 30 inches, yellowish-brown (10YR 5/4) and brown (10YR 5/3) fine sand; massive; clay bridging; slightly coherent; medium acid.

B32—30 to 40 inches, variegated brown (10YR 5/3), grayish-brown (10YR 5/2), and yellowish-brown (10YR 5/4) sand and fine sand; massive; some clay bridging; slightly coherent; slightly acid.

C—40 to 50 inches, brown (10YR 5/3) and grayish-brown (10YR 5/2) sand and coarse sand; single grain; loose; calcareous.

The Ap horizon is typically loam, but in places it is sandy loam and in spots silt loam. It ranges from very dark gray (10YR 3/1) to very dark brown (10YR 2/2). The B horizon ranges from sandy clay loam to clay and has weak to strong blocky structure. The thickness of the solum is typically 30 to 40 inches but ranges from 24 to 42 inches. The underlying material is typically fine sand and sand. In spots it is gravelly. In places the substratum contains very thin textural bands that range from loamy fine sand to silty clay loam. The A horizon is neutral or slightly acid. The B horizon is slightly acid or medium acid. In many places the substratum is leached of free lime carbonates in the upper part but becomes calcareous within a depth of 60 inches.

Kasota soils have a more clayey subsoil than the well-drained Wadena and Fairhaven soils.

Kasota loam, 0 to 2 percent slopes (KaA).—In a few areas the surface layer is silt loam. The depth to sand and gravel is typically 30 to 36 inches but ranges from 24 to 42 inches.

This soil tends to be deficient in moisture during long dry spells but is very good for crops and pasture. (Capability unit IIs–1; woodland group 1; building site group 1)

Kasota loam, 2 to 6 percent slopes, eroded (KaB2).—This soil has gently undulating, fairly long, smooth slopes. It has lost 3 to 6 inches of its original surface layer through erosion. The present plow layer is a brownish mixture of the original surface layer and material from the subsoil. The organic-matter content is low to moderate. Generally the depth to sand and gravel is 24 to 30 inches. Included in mapping were a few areas that have been used mainly for pasture and are only slightly eroded.

This soil is good for small grain and pasture. The moderate moisture-storage capacity is a limitation. Further erosion will make the soil more droughty. (Capability unit IIe–4; woodland group 1; building site group 1)

Kasota sandy loam, 0 to 2 percent slopes (KsA).—This soil is only 24 to 36 inches deep over sand and gravel. The clayey subsoil retains moisture. Included in mapping were a few spots where the surface layer is loamy sand.

This soil is good for small grain and pasture, but it is too droughty to be good for corn. Wind erosion is a hazard. (Capability unit IIIs–1; woodland group 4; building site group 1)

Kasota sandy loam, 2 to 6 percent slopes, eroded (KsB2).—This soil has gently undulating, fairly smooth, short slopes. In most areas it has lost one-third to two-thirds of its original surface layer through erosion. In these areas the plow layer is a brownish mixture of the original surface layer and material from the subsoil and is low in organic-matter content. The depth to sand and gravel is only 24 to 30 inches. The clayey subsoil retains moisture. Included in mapping were a few spots where the surface layer is loamy sand.

This soil is fairly good for small grain and pasture, but it is too droughty to be good for corn. Erosion is a hazard. (Capability unit IIIe–4; woodland group 4; building site group 1)

Lester Series

Soils of the Lester series are the most extensive in the county. They are undulating to hilly, deep, well-drained soils that formed in friable, limy, loamy glacial till. The original vegetation consisted of prairie grasses on which deciduous hardwoods encroached. The topography is morainic.

The surface layer is friable, very dark gray loam. It is about 7 inches thick, has moderate granular structure, and is slightly acid. The subsurface layer, about 2 inches thick, is dark-gray and dark grayish-brown, friable loam that has weak platy structure. This layer also is slightly acid.

The subsoil is about 31 inches thick. The uppermost part is friable, slightly acid, dark-brown loam. It has weak blocky structure, and there are grayish silica coatings and dark-colored organic stains on the peds. The middle part of the subsoil is dark yellowish-brown to yellowish-brown, friable, medium acid clay loam. It has moderate blocky structure, and there are dark-brown films of clay and of organic matter on the peds. The lowermost part has weak blocky structure and has fewer films of clay and of organic matter on the peds than the middle part.

The underlying material is grayish-brown to light olive-brown, limy clay loam or loam that is friable and structureless (fig. 11).

Natural fertility is high. The organic-matter content is high. Runoff is medium to rapid, depending on the slope. Permeability is moderate, and the moisture-storage capacity is high.

The undulating to sloping soils are well suited to all of the common crops. The hilly soils, which are subject to severe erosion, are used mostly for hay and pasture. Most of the acreage is either cultivated or pastured. A few areas are wooded.

Typical profile of Lester loam (wooded pasture; 6 percent slope; SW¼NW¼ sec. 7, T. 115 N., R. 25 W.):

A1—0 to 7 inches, very dark gray (10YR 3/1) loam; moderate, fine, granular structure; friable; high organic-matter content; abundant grass roots; slightly acid; clear, smooth boundary.

A2—7 to 9 inches, dark-gray (10YR 4/1), dark grayish-brown (10YR 4/2), and gray (10YR 5/1) loam; weak, thin, platy structure that breaks to weak, fine, granular; friable; many roots; slightly acid; clear, smooth boundary.

B1—9 to 14 inches, dark-brown (10YR 4/3) loam; thick, light brownish-gray (10YR 6/2), dusty silica coatings and very dark grayish-brown (10YR 3/2) organic stains; weak, fine, subangular blocky structure; friable; many roots; slightly acid; clear, smooth boundary.

B21—14 to 19 inches, dark yellowish-brown (10YR 4/4) clay loam; moderate, fine, subangular blocky structure; dark grayish-brown (10YR 4/2) exteriors with dark-brown (10YR 3/3) organic stains and light brownish-gray (10YR 6/2), dusty silica coatings; continuous, distinct, clay films on vertical ped faces and patches on horizontal ped faces; friable; many roots; medium acid; clear, smooth boundary.

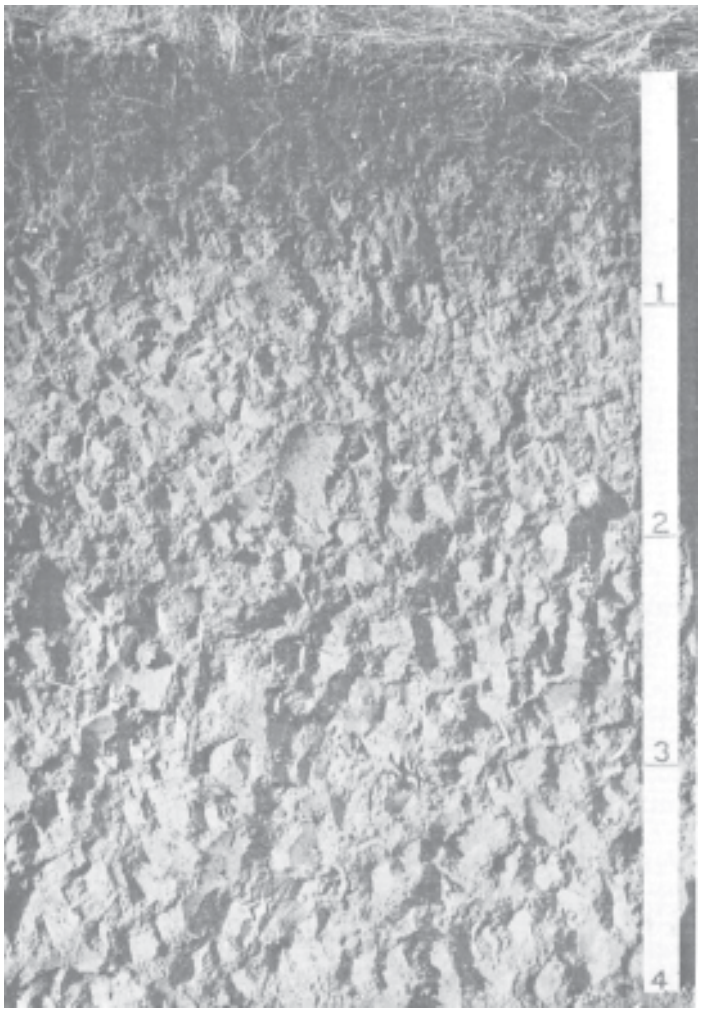


Figure 11.—**Profile of Lester loam.**

B22—19 to 28 inches, yellowish-brown (10YR 5/4) clay loam; weak, medium, prismatic structure that breaks to moderate, fine, subangular blocky; dark-brown (10YR 3/3 and 4/3) exteriors and root channels; continuous distinct clay films on vertical ped faces and discontinuous films on horizontal ped faces; some peds have continuous distinct clay films on all faces; friable; few fine shale fragments; medium acid; clear, smooth boundary.

B23—28 to 40 inches, light olive-brown (2.5Y 5/4) to yellowish-brown (10YR 5/4) clay loam; weak, fine, subangular blocky structure; dark brown (10YR 3/3) and very dark brown (10YR 2/2) organic stains in old root channels and on some ped faces; discontinuous clay films on vertical faces; friable; few fine shale fragments; medium acid; clear, smooth boundary.

C—40 to 48 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) loam; massive; friable; very dark grayish-brown (10YR 3/2) organic-matter stains in old root channels; few reddish-orange iron stains; calcareous.

In spots the A1 horizon is silt loam or clay loam. It ranges from 5 to 10 inches in thickness, but in uneroded areas it is typically 6 to 8 inches thick. The incipient to fairly distinct A2 horizon is 1 to 5 inches thick. It has weak, very fine, subangular blocky structure to weak, thin, platy structure. Both the A1 and the A2 horizons are neutral or slightly acid. The B horizon is typically clay loam but ranges to loam; it has a higher clay content than either the A horizon or the C horizon. It ranges from slightly acid to strongly acid. This layer has weak to strong, fine and medium, blocky structure to fine and medium prismatic structure. The blocks generally have discontinuous or continuous clay films. In many places peds in the upper part of the B horizon have coatings of silica flour that has filtered down from the A2 horizon. Generally the solum is 24 to 42 inches thick. Limy loam or clay loam glacial till is typically at a depth of 36 to 42 inches. There are a few stones and boulders and varying numbers of shale fragments on the surface and throughout the profile.

Lester soils have a thicker, darker colored surface layer and a less distinct subsurface layer than the well-drained Hayden soils. They are better drained than the moderately well drained LeSueur soils, which generally occupy flats and slight rises.

Lester loam, 2 to 6 percent slopes (LaB).—In most places this soil is undulating. Some areas have irregular slopes and include spots of moderately well drained LeSueur soils and poorly drained Cordova and Webster soils.

This soil is suited to all general farm crops. The erosion hazard is moderate. (Capability unit IIe–2; woodland group 1; building site group 4)

Lester loam, 2 to 6 percent slopes, eroded (LaB2).—This soil has undulating slopes that, for the most part, are short and irregular. Erosion has removed between 3 and 6 inches of the original surface layer, and the present plow layer is a mixture of the original dark-colored surface layer and brownish, finer textured material from the subsoil. The organic-matter content is moderate to low. Included in mapping were poorly drained depressions, which occur in areas where slopes are uneven, and on the more abrupt slopes, spots of yellowish, limy clay loam, called "bald spots."

This soil has poor tilth because of the loss of organic matter. Nevertheless, it is very good for crops and pasture. The erosion hazard is moderate. (Capability unit IIe–2; woodland group 1; building site group 4)

Lester loam, 6 to 12 percent slopes (LaC).—This soil has rolling slopes that range from short and irregular to fairly long and smooth. Included in mapping the more complex slopes were small depressional areas of Webster and Glencoe soils. This soil is suitable for crops and pasture, but the erosion hazard is severe. Most of the acreage is pasture or woods. Part of it has recently been cleared and used for crops. (Capability unit IIIe–1; woodland group 2; building site group 5)

Lester loam, 6 to 12 percent slopes, eroded (LaC2).—This soil has rolling slopes that range from short and irregular to fairly long and smooth. Erosion has removed 3 to 6 inches of the original surface layer, and the present plow layer is a mixture of the original grayish-brown surface material and the finer textured subsoil material. Included in mapping the more complex slopes were a few, small, wet depressions; a few small gullies; and, on the more abrupt slopes, some spots of yellowish, limy clay loam, called "bald spots."

This soil has poor tilth because of the loss of organic matter. It is good for pasture and moderately good for crops. The erosion hazard is severe in cultivated areas. (Capability unit IIIe–1; woodland group 2; building site group 5)

Lester loam, 12 to 18 percent slopes, eroded (LaD2).—In most cultivated areas of this soil, erosion has removed 3 to 6 inches of the original surface layer. The present plow layer is a mixture of the original surface layer and the finer textured subsoil. It is lighter colored than the

original layer. The organic-matter content is moderate to low. Included in mapping were spots of Webster and Glencoe soils in depressions; limy, yellowish spots on the edges of ridges; and slightly eroded areas in pasture or woods.

This soil generally has poor tilth because of the loss of organic matter. It is moderately good for pasture and fair for crops. The erosion hazard is severe. (Capability unit IVe-1; woodland group 2; building site group 6)

Lester-Estherville complex, 2 to 6 percent slopes (leB).—This unit is about 65 percent Lester loam, 20 percent Estherville sandy loam, and 15 percent Estherville loam. Estherville soils are described under the heading "Estherville Series." All of these soils are gently undulating. Slopes are generally short and irregular. Erosion has removed as much as 6 inches of the original surface layer in most cultivated areas but has been slight in pastured or wooded areas. Included in mapping were a few spots where the surface is covered with gravel.

These soils are good for crops and pasture. The erosion hazard is moderate. Estherville soils are droughty. (Capability unit IIe-4; woodland group 1; building site group 4)

Lester-Estherville complex, 6 to 12 percent slopes, eroded (leC2).—This unit is 45 percent Lester loam, 40 percent Estherville sandy loam, and 15 percent Estherville loam. Estherville soils are described under the heading "Estherville Series." All of these soils have rolling, short, and irregular slopes. In cultivated areas erosion has removed as much as 6 inches of the original surface layer and the present plow layer is a mixture of the original grayish-brown surface layer and material from the subsoil. Pastured and wooded areas are only slightly eroded. The organic-matter content is generally low. Included in mapping were spots where the surface is covered with gravel and spots of yellowish, limy clay loam, called "bald spots."

These soils are good for pasture and moderately good for crops. The erosion hazard is severe. The Estherville soils of this mapping unit are droughty. (Capability unit IIIe-3; woodland group 2; building site group 5)

LeSueur Series

The LeSueur series consists of deep, nearly level to gently undulating, moderately well drained soils that formed in friable, limy glacial till. These soils are in the uplands, mainly in the southern and western parts of the county. The original vegetation consisted of prairie grasses on which deciduous hardwoods encroached.

The surface layer is black, friable clay loam. It is about 9 inches thick, has moderate granular structure, and is slightly acid. The subsurface layer is similar, but it is about 2 inches thick and is slightly lighter colored than the surface layer.

The subsoil is very dark grayish-brown and dark grayish-brown, medium acid clay loam. It is about 19 inches thick. The uppermost part has moderate blocky structure and dusty silica coatings. The middle part has moderate to strong blocky structure and prismatic structure. The blocks have very dark brown organic stains and clay films. The lowermost part has faint, light olive-brown mottles, moderate blocky structure, and very dark brown organic stains and clay films on the blocks.

The underlying material is dark grayish-brown and grayish-brown, limy clay loam glacial till distinctly mottled with light olive brown. It is friable and massive.

Figure 12 shows a profile of LeSueur clay loam.

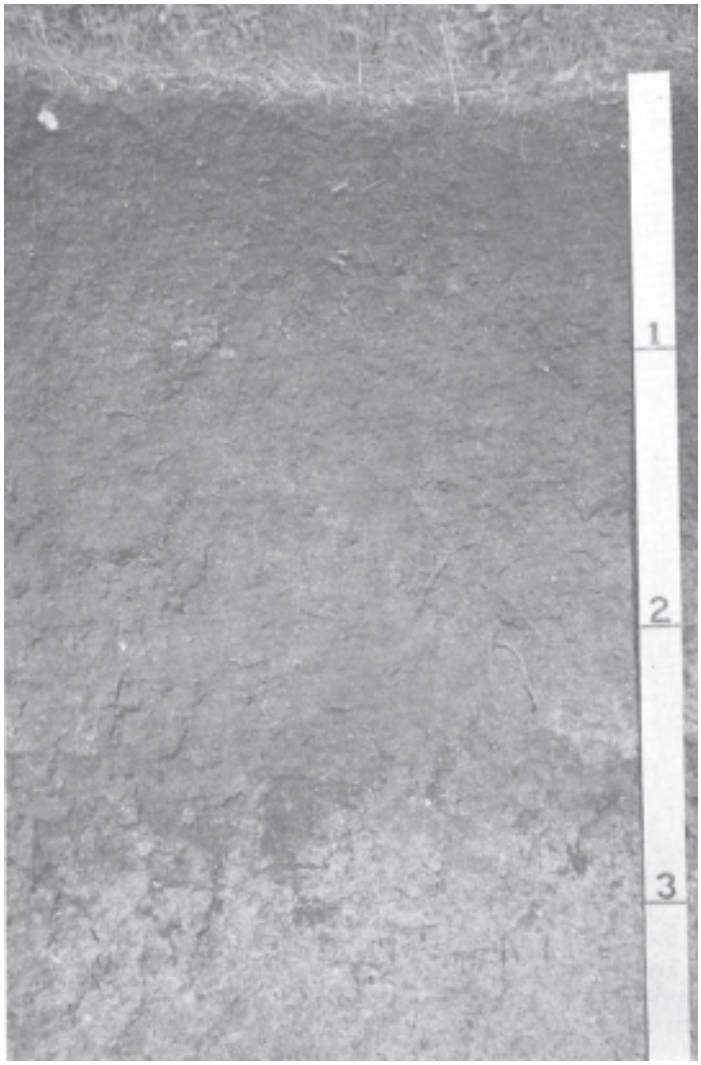


Figure 12.—**Profile of LeSueur clay loam.**

Natural fertility is high. The organic-matter content is high. Runoff is medium, and permeability is moderate. The movement of air and water is slightly restricted.

These soils are well suited to all of the common crops. Most of the acreage is cultivated. Part of it is wooded pasture.

Typical profile of LeSueur clay loam (wooded pasture; 1 percent slope; NW¼NW¼ sec. 11, T. 117 N., R. 26 W.):

A1—0 to 9 inches, black (10YR 2/1) clay loam; moderate, fine and medium, granular structure; friable; high organic-matter content; matted roots; slightly acid; clear, wavy boundary.

A2—9 to 11 inches, very dark gray (10YR 3/1) clay loam; moderate, fine, granular structure; friable; many roots; slightly acid; discontinuous boundary.

B1—11 to 16 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) clay loam; moderate, very fine, subangular blocky structure; gray (10YR

5/1, 6/1, dry) silica coatings; friable; many roots; medium acid; clear, smooth boundary.

B21—16 to 21 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) clay loam; very dark brown (10YR 2/2) organic stains; moderate to strong, very fine and fine, subangular blocky structure; continuous, distinct clay films on vertical faces and patches on horizontal faces; firm to friable; medium acid; clear, smooth boundary.

B22—21 to 26 inches, dark grayish-brown (10YR–2.5Y 4/2) and very dark grayish-brown (10YR 3/2) clay loam; very dark brown (10YR 2/2) organic stains; moderate, fine, prismatic structure breaks to moderate to strong, fine, subangular blocky structure; continuous, distinct clay films on all faces; firm; medium acid; clear, smooth boundary.

B23—26 to 30 inches, dark grayish-brown (2.5Y 4/2) clay loam; few, fine, faint, light olive-brown mottles; very dark brown (10YR 2/2) organic stains; moderate, fine, subangular blocky structure; continuous, distinct clay films on vertical faces and patches on horizontal faces; firm; medium to slightly acid; clear, smooth boundary.

C1—30 to 33 inches, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) clay loam; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; massive; friable; slightly calcareous; clear, smooth boundary.

C2—33 to 40 inches, grayish-brown (2.5Y 5/2) clay loam; many, fine, distinct, light olive-brown (2.5Y 5/4 and 5/6) mottles; massive; friable; calcareous.

The A horizon is typically clay loam, but in places it is loam and in spots silty clay loam. It ranges from 6 to 12 inches in thickness. The incipient to distinct A2 horizon is 1 to 4 inches thick. It has weak to moderate, fine, granular structure or weak, thin, platy structure. The B horizon is typically clay loam but shows a marked increase in clay content in comparison with the A1 horizon and the underlying material. It has moderate to strong, fine and medium, blocky structure to fine and medium prismatic structure. The uppermost part typically has silica coatings that have filtered down from the A2 horizon. There are patchy to continuous clay films on the peds. Typically, the solum is 30 to 42 inches thick. The B horizon is typically medium acid but in places is strongly acid. There are a few stones and boulders on the surface and throughout the profile and varying numbers of shale fragments.

LeSueur soils have a thicker, darker colored surface layer than the well-drained Lester soils, and their subsoil is more grayish and has variable degrees of mottling. They are more intensively mottled than the poorly drained Cordova and Webster soils and lack the distinctive gray coloring in the subsoil.

LeSueur clay loam, 0 to 2 percent slopes (LsA).—Included with this soil in mapping were spots of poorly drained Webster or Cordova soils and a few areas in the south-central part of the county where the soils have a somewhat finer textured subsoil.

This soil is well suited to crops. If well managed, it can be farmed intensively to row crops. It is also good for pasture. (Capability unit I–1; woodland group 1; building site group 8)

LeSueur clay loam, 2 to 6 percent slopes (LsB).—Included with this soil in mapping were hummocky areas and small wet depressions.

This soil is very good for crops and pasture. Erosion is a hazard. (Capability unit IIe–1; woodland group 1; building site group 8)

Marsh

Marsh (Ma) occupies shallow lakes and ponds that are dry during periods of less than normal precipitation. Most areas are wet throughout the year. Recently, a few areas have been artificially drained. The vegetation consists of cattails, rushes, sedges, and other water-tolerant plants.

Marsh is ideal for wildlife. It makes very poor pasture. Drained areas can be used for crops. Wild hay can be cut along the edges of the marsh. (Capability unit VIIIw–1; woodland group 9; building site group 10)

Mayer Series

The Mayer series consists of loamy, nearly level, poorly drained soils that are moderately deep over limy sand and gravel. These soils are on flats and in drainageways on outwash plains and stream terraces. Fairly extensive areas occur on outwash plains of the South Fork Crow River. The original vegetation was prairie grass.

The surface layer is black to very dark gray, friable loam. It is about 14 inches thick and has weak to moderate blocky structure. It contains fine fragments of snail shells and is limy. The subsurface layer, which is about 4 inches thick, is very dark gray, friable loam or sandy clay loam that has lighter colored grayish streaks. It also is limy, has weak blocky structure, and contains a few fragments of snail shells.

The subsoil is mottled olive-gray and olive, friable sandy clay loam or loam and is about 15 inches thick. The lower part is massive, limy sandy clay loam or sandy loam.

The underlying material is brownish and grayish, loose, limy sand and gravel.

Natural fertility is moderately high. The organic-matter content is high. Runoff is slow, permeability is moderately rapid, and the moisture-storage capacity is moderate. The water table is seasonally fairly high.

Mayer soils are used for general farming. Drained areas are well suited to all of the common crops, especially corn and soybeans. Undrained areas are used mainly for pasture.

Typical profile of Mayer loam (bluegrass pasture; 1 percent slope; SE¼SW¼ sec. 34, T. 117 N., R. 26 W.):

A11—0 to 10 inches, black (N 2/0 to 10YR 2/1) loam; weak to moderate, very fine, subangular blocky structure; friable; many very fine fragments of snail shells; many roots; calcareous; clear, smooth boundary.

A12—10 to 14 inches, black (10YR 2/1) to very dark gray (10YR 3/1) loam; weak to moderate, very fine, subangular blocky structure; friable; few fine fragments of snail shells; few roots; calcareous; gradual, wavy boundary.

A3g—14 to 18 inches, very dark gray (10YR 3/1) loam or light sandy clay loam; streaks of dark gray (10YR to 5Y 4/1), gray (5Y 5/1), and olive gray (5Y 5/2); weak, very fine, subangular blocky structure; friable; few fine fragments of snail shells; few roots; calcareous; gradual, wavy boundary.

B21g—18 to 25 inches, olive-gray to light olive-gray (5Y 5/2 to 6/2) sandy clay loam; few, fine, faint and distinct, olive-gray (5Y 4/2) and olive-brown (2.5Y 4/4) mottles; weak, very fine, subangular blocky structure; friable; calcareous; clear, smooth boundary.

B22g—25 to 28 inches, olive (5Y 5/3) sandy clay loam; some fine gravel; many, fine, faint, olive-gray (5Y 5/2 and 4/2) mottles; massive; friable; calcareous; clear, smooth boundary.

B23g—28 to 33 inches, olive (5Y 5/3) sandy loam or sandy clay loam; some fine gravel; many, fine, faint olive-gray (5Y 5/2 and 4/2) mottles; massive; friable; calcareous; clear, smooth boundary.

C—33 to 48 inches, dark-brown (10YR 4/3), brown (10YR 5/3), and grayish-brown (10YR 4/2) fine gravel and coarse sand; single grain; loose; calcareous.

The A horizon is typically loam. The A1 horizon ranges from 12 to 24 inches in thickness. In places it is high in lime and has a distinct grayish cast when dry. The B horizon is mottled

olive, dark-gray, or olive-gray loam or sandy clay loam. Its clay content is between 18 and 27 percent. The underlying material consists of coarse sand, very coarse sand, and fine gravel or strata of gravel and sand. It is at a depth of 24 to 42 inches. The profile is weakly to strongly calcareous.

Mayer soils differ from the poorly drained Biscay soils in being calcareous in the material above the substratum. They have coarser textured material above the substratum than the poorly drained Talcot soils, which are more likely to be ponded, and have a thicker, darker colored surface layer and a more abruptly and intensively gleyed subsoil. Mayer soils are coarser textured than the poorly drained Canisteo soils, which formed in glacial till.

Mayer loam (My).—In some areas, especially on the slightly elevated rims around depressions, this soil has fine shell fragments on the surface. Included in mapping were a few spots where the surface layer is strongly limy.

If adequately drained, this soil is well suited to corn and soybeans. The content of lime is a minor limitation that can be offset by applying large amounts of potash and phosphate. Excess water is a moderate limitation. (Capability unit IIw–1; woodland group 8; building site group 9)

Oshawa Series

The Oshawa series consists of deep, silty, very poorly drained soils on flood plains. These soils occupy old stream channels and oxbow lakes along the Minnesota River. They are frequently ponded. The native vegetation consisted of rushes, sedges, willows, and rank grasses.

The surface layer is dark gray to very dark gray, friable silty clay loam. It is limy and massive and is about 7 inches thick. The underlying material also is limy, massive silty clay loam. It is very dark gray and dark gray mottled with dark brown and olive gray. It contains a few fine fragments of shells.

At a depth of about 30 inches is dark olive-gray silty clay loam mottled with dark brown. It is limy, friable, and massive.

Natural fertility is high. The organic-matter content is high. Permeability is moderately slow, and the moisture-storage capacity is high. The water table is always high.

These soils cannot be used for crops unless they are protected from flooding and then artificially drained. None of the acreage is cultivated. Most of it is idle.

Typical profile of Oshawa silty clay loam (old stream channel; marsh vegetation; less than 1 percent slope; NE¼NE¼ sec. 12, T. 114 N., R. 24 W.):

A—0 to 7 inches, dark gray (5Y 4/1) to very dark gray (5Y 3/1) silty clay loam; massive; friable when moist, plastic and slightly sticky when wet; calcareous.

C1—7 to 24 inches, very dark gray (5Y 3/1) and dark gray (5Y 4/1) silty clay loam; few, fine, faint, olive-gray (5Y 4/2) and dark olive-gray (5Y 3/2) mottles; many, fine, distinct, dark-brown (7.5YR 4/2 and 3/2) mottles; massive; friable when moist, plastic and sticky when wet; few, fine shell fragments; calcareous.

C2—24 to 30 inches, very dark gray (5Y 3/1) and dark gray (5Y 4/1) silty clay loam; blotches of black (5Y 2/1); many, fine, faint, dark-brown (7.5YR 4/2 and 3/2) mottles; massive; friable when moist, very plastic and sticky when wet; calcareous.

C3—30 to 40 inches, dark olive-gray (5Y 3/2) silty clay loam; few, fine, faint, dark-brown (7.5YR 4/2 and 3/2) mottles; massive; friable when moist, very plastic and sticky when wet; calcareous.

The entire profile is typically silty clay loam. In spots it contains thin lenses of silt or very fine sand. In a few areas the surface layer is silt loam. In some areas the surface is covered with a few inches of fibrous peat or silty muck. The combined thickness of the surface and subsurface layers ranges from 24 to more than 48 inches.

Oshawa soils occupy deeper, wetter positions on the landscape than the poorly drained Chaska soils. They are lighter colored than the poorly drained Comfrey soils.

Oshawa silty clay loam (Os).—This soil occupies old stream channels of the Minnesota River. Many areas are ponded throughout the year.

This soil provides very good habitat for wildlife. It is only fair for pasture and wild hay. It is unsuitable for crops unless the threat of flooding is removed. Most of the acreage is in pasture. The vegetation consists of willows, grasses of the kinds that grow in marshes, and sedges. (Capability unit VIw–1; woodland group 9; building site group 11)

Peat and Muck

Peat and muck are dark-brown, organic soils in wet depressions and drainageways. Peat consists mainly of partly decomposed plant remains. Muck has undergone more decomposition than peat and has a higher percentage of silt and clay.

Peat and muck, calcareous (Pc).—In the uplands these soils are generally 12 to 42 inches thick. In old channels of the Minnesota River, they are generally more than 42 inches thick. There are small shell fragments on the surface and throughout the material.

These soils are wet and marshy part of the year, but they generally dry out by midsummer. They are poor for pasture and hay crops. Drained areas are well suited to corn and to truck crops, such as onions and potatoes. Occasionally, crops are seriously damaged by a late-summer frost. Wetness is a severe limitation. (Capability unit IIIw–2; woodland group 9; building site group 10)

Peat and muck, deep (Pd).—These soils are ordinarily 3½ to 6 or 7 feet thick, but in some areas they are more than 20 feet thick. They occur throughout the county. The largest bogs are in old lake bottoms. The peat is the more extensive. The underlying material ranges from silty clay to sand and gravel.

These soils are wet and marshy part of the year, but they generally dry out by midsummer. Drained areas are well suited to corn and to truck crops, such as onions and potatoes. Occasionally, crops are damaged by a frost late in summer. Wetness is a severe limitation. (Capability unit IIIw–2; woodland group 9; building site group 10)

Peat and muck, moderately shallow, over loam (Pm).—These soils are 12 to 42 inches thick. They occur throughout the uplands. In some areas they are covered with a thin mantle of mineral soil that has been washed from nearby slopes. The underlying material is olive-gray loam to clay loam. The peat is generally raw, but where it has been drained and cultivated it has undergone more decomposition. The peat is the more extensive.

Drained areas are well suited to corn and to truck crops, such as onions and potatoes. Undrained areas are fair for pasture and hay crops. Damage from a late-summer frost is a hazard. Wetness is a severe limitation. (Capability unit IIIw–2; woodland group 9; building site group 10)

Peat and muck, moderately shallow, over sand (Ps).—These soils are 12 to 42 inches thick. They occur mainly in

depressions on sandy outwash plains and stream terraces. There are a few areas along the edges of sand-bottom lakes.

These soils are too wet to be suitable for crops. Practically all of the acreage is in pasture and wild hay. Fertility is very low. These soils shrink rapidly if they are farmed intensively; after a few years of cultivation, there is nothing left but the underlying sand. (Capability unit Vw–1; woodland group 9; building site group 10)

Rasset Series

The Rasset series consists of loamy, nearly level to hilly, somewhat excessively drained soils that formed over sand. These soils are on outwash plains of the Minnesota River. The original vegetation consisted of grasses on which deciduous hardwoods encroached.

The surface layer is very dark grayish-brown, very friable loamy sand. It is about 8 inches thick, has weak granular structure, and is slightly acid. The subsurface layer is similar, but it is about 3 inches thick and is browner than the surface layer.

The subsoil is slightly acid and is about 29 inches thick. The uppermost part is very dark brown to dark grayish-brown sandy loam. It is friable and has weak blocky structure. The middle part is dark-brown sandy loam grading to dark yellowish-brown sandy clay loam. It also is friable and has weak blocky structure. The lowermost part is yellowish-brown, massive loamy sand grading to sand.

The underlying material is brown, loose, slightly acid sand.

These soils are droughty. They warm up early in spring and dry out quickly after a rain. They are easy to till. Natural fertility is low. Runoff is medium, permeability is moderately rapid, and the moisture-storage capacity is low.

These soils are used for general farming. They are suitable for small grain. They are too droughty to be suitable for corn.

Typical profile of Rasset loamy sand (alfalfa field; 2 percent slope; SE¼SE¼ sec. 25, T. 115 N., R. 24 W.):

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; slightly acid.

A3—8 to 11 inches, very dark gray (10YR 3/1) to very dark brown (10YR 2/2) loamy sand; weak, fine, granular structure; friable; slightly acid.

B21—11 to 15 inches, very dark brown (10YR 2/2) sandy loam; weak, fine and very fine, subangular blocky structure; friable; slightly acid.

B22—15 to 17 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, very fine and fine, subangular blocky structure; clay bridging; friable when moist, slightly sticky when wet; slightly acid.

B23—17 to 21 inches, dark-brown (10YR 4/3) sandy loam; weak, very fine and fine, subangular blocky structure; friable when moist, slightly sticky when wet; slightly acid.

B24—21 to 24 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; weak, fine, subangular blocky structure; clay bridging; friable when moist, slightly sticky when wet; slightly acid.

B25—24 to 31 inches, yellowish-brown (10YR 5/4) loamy sand; massive; clay bridging; very friable when moist, slightly sticky when wet; slightly acid.

B26—31 to 40 inches, yellowish-brown (10YR 5/4) sand or loamy sand; massive; clay bridging; very friable when moist, slightly sticky when wet; slightly acid.

C—40 to 54 inches, brown (10YR 5/3) sand; single grain; loose; slightly acid.

The A horizon is typically loamy sand, but in places it is sandy loam, and in spots it is sand. The B horizon shows a marked increase in clay content in comparison with content in the A horizon. It ranges from sandy loam to sandy clay loam and typically contains transitional layers of loamy sand or sand that have clay bridging. The substratum is predominantly sand. In places it contains thin loamy bands. If these bands occur within a depth of 48 inches, they are generally loamy sand or sandy loam. The entire profile is slightly acid or medium acid, generally to a depth of more than 48 inches.

Rasset soils have a finer textured subsoil and generally are less droughty than the excessively drained Hubbard soils. They have a sandier substratum and are more deeply leached than Estherville soils.

Rasset loamy sand, 0 to 6 percent slopes (RaB).—This soil is gently undulating. In a few areas the surface layer is sandy loam. Erosion has been slight in pastured and wooded areas but has removed as much as 6 inches of the original surface layer in cultivated areas. Generally the eroded soils are very low in organic-matter content.

This soil is droughty. It is fair for small grain and pasture, but generally it is too droughty for corn. Controlling erosion is a serious problem. (Capability unit IVs–1; woodland group 6; building site group 1)

Rasset loamy sand, 6 to 12 percent slopes (RaC).—This soil has strong, generally short slopes. In a few areas the surface layer is sandy loam. Erosion has been slight in pastured and wooded areas but has removed as much as 6 inches of the original surface layer in cultivated areas. Generally the eroded soils are very low in organic-matter content.

Droughtiness is a severe limitation. Controlling erosion is a serious problem. (Capability unit VIs–1; woodland group 6; building site group 2)

Rasset loamy sand, 12 to 18 percent slopes (RaD).—In a few areas the surface layer of this soil is sandy loam. Erosion has been slight in pastured or wooded areas but has removed as much as two-thirds of the original surface layer in cultivated areas. This soil is unsuitable for crops. It ought to be kept in permanent vegetation. Droughtiness is a severe limitation, and the erosion hazard is severe. (Capability unit VIIs–1; woodland group 7; building site group 3)

Salida Series

The Salida series consists of sandy, moderately steep to steep, excessively drained soils that are very shallow over limy gravel and sand.

The surface layer is very dark gray loamy sand. It is about 4 inches thick, is very friable, and has weak granular structure. This layer is neutral.

The subsoil is very dark grayish-brown, loose loamy coarse sand. It is about 6 inches thick, has weak granular structure, and is limy.

The limy underlying material is grayish-brown, loose coarse sand and gravel.

These soils are droughty. Natural fertility is very low. Runoff is slow to medium, depending on the slope, and permeability is very rapid. Most of the precipitation is absorbed and then passes quickly through the soil. The moisture-storage capacity is very low. The root zone is limited.

These soils are too droughty to be suitable for crops.

The moderately steep slopes are used mainly for pasture and hay crops. The steeper slopes are wooded or are idle.

Typical profile of Salida loamy sand (bluegrass pasture; 19 percent slope; NW¼NW¼ sec. 15, T. 114 N., R. 24 W.):

A1—0 to 4 inches, very dark gray (10YR 3/1) loamy sand; weak, fine and medium, granular structure; very friable; neutral; clear, wavy boundary.

B—4 to 10 inches, very dark grayish-brown (10YR 3/2) loamy coarse sand; weak, fine, granular structure; loose; calcareous; clear, irregular, and discontinuous boundary.

C—10 to 42 inches, grayish-brown (10YR 5/2) coarse sand and gravel; single grain; loose; calcareous.

The A1 horizon ranges from loamy sand to coarse sandy loam in texture and from 4 to 8 inches in thickness. The B horizon is either very thin or is discontinuous. It ranges from loamy coarse sand and coarse sandy loam to fine gravel and coarse sand that contains some fines. In places the underlying material contains stones, cobblestones, and boulders. The A horizon ranges from neutral to slightly calcareous. The B horizon and the underlying material are calcareous.

Salida soils are much coarser textured and much shallower to sand and gravel than the somewhat excessively drained Estherville soils. They have a much thinner surface layer than the excessively drained Sandy colluvial land.

Salida loamy sand, 18 to 40 percent slopes (SaF).—This soil is characterized by narrow terrace escarpments and irregular ridges, hills, and bluffs. Generally it is only 4 to 10 inches deep over sand and gravel. In a few areas the surface is gravelly. Many areas are dissected by broad, deep gullies.

This soil is very droughty and is unfit for crops. Most of the acreage is pastured or wooded. (Capability unit VIIs–1; woodland group 7; building site group 3)

Sandy Colluvial Land

Sandy colluvial land (Sc) consists of deep, sandy, gently sloping to moderately steep, excessively drained soil material that has been deposited at the base of steep slopes. This material occurs below bluffs in the Minnesota River valley. Parts of it are dissected by deep gullies. In many areas there are detrimental deposits of sand and gravel from gullies that are cutting down from nearby steeper slopes (fig. 13).

Figure 13.—**Deposits of sand and gravel on Sandy colluvial land. Salida soils in background.**

This soil material is neutral or slightly acid. Natural fertility is low. The moisture-storage capacity is very low.

Generally this material is not used for crops, because it is droughty and occurs as such odd-sized areas that it is not readily accessible. It is suitable for pasture early in spring. Controlling erosion is a serious problem. (Capability unit IVs–1; woodland group 6; building site group 8)

Sandy Lake Beaches

Sandy lake beaches (Sk) surround lakes and old lakebeds of former lakes. They vary in width. In places they are some distance from the present lakeshore, on low narrow ridges or bars that were pushed up by ice. Areas near existing lakes are generally submerged when the water is high.

The soil material varies in color and texture and lacks profile development. It is generally dark colored to moderately dark colored coarse sand or loamy coarse sand. In a few areas it is medium textured to moderately fine textured and is covered with a thin mantle of peat or muck. The water table is generally high, depending on the season and nearness to the lake. Drainage ranges from excessive to very poor.

This soil material is very low in fertility. It is mildly alkaline to slightly acid.

Sandy lake beaches are not generally used for farming. Most areas support a thin stand of grass and a few willows. (Capability unit VIIs–1; woodland group 6; building site group 10)

Storden Series

The Storden series consists of deep, rolling to hilly, well-drained soils that formed in friable, limy clay loam or loam glacial till. These soils are in the uplands, mainly in the western part of the county. The native vegetation was grass.

The surface layer is very dark grayish-brown, friable loam. It is slightly limy. This layer is cloddy.

The underlying material is light olive-brown, friable clay loam glacial till. It is limy and massive.

Natural fertility is medium. The organic-matter content is medium. Runoff is rapid. Permeability is moderate, and the moisture-storage capacity is moderate. Water does not enter the soil easily. The concentration of carbonates in the profile reduces the rates of both infiltration and permeability.

These soils are used for general farm crops. They are well suited to alfalfa. The stronger slopes are used mainly for pasture and hay crops.

In this county Storden soils are mapped with Lester soils.

Typical profile of Storden loam (cultivated field; 16 percent slope; SW¼SW¼ sec. 36, T. 117 N., R. 26 W.):

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; cloddy; friable when moist, slightly plastic when wet; slightly calcareous; abrupt, smooth boundary.

C—6 to 48 inches, light olive-brown (2.5Y 5/4) clay loam; massive; friable when moist, slightly plastic and sticky when wet; calcareous.

The Ap horizon ranges from loam to clay loam. It is generally slightly limy, but in places it is neutral. The depth to limy material is typically less than 12 inches. There are stones and

boulders on the surface and throughout the soil, and varying numbers of small shale fragments. The B horizon is either lacking, or it is less than 6 inches thick and is discontinuous.

These soils are not so well developed as the well-drained Lester soils and are less deep to limy material. They are closely associated with the poorly drained Webster soils, which are on flats, and the very poorly drained Glencoe soils, which are in depressions.

Storden-Lester loams, 6 to 12 percent slopes, eroded (SlC2).—These are rolling soils on irregular, short ridges and knolls. About 60 percent of the unit is Storden loam, and 40 percent is Lester loam. For a description of Lester soils, refer to "Lester Series." The plow layer is a mixture of the original dark-gray surface layer and brownish, finer textured material from the subsoil. There are many bald spots of yellowish, limy clay loam on the short ridges and knolls and spots of Glencoe and Webster soils in depressions in areas where slopes are irregular.

These soils are very low in organic-matter content and have poor tilth. They are fair for crops and good for pasture. The erosion hazard is severe in cultivated areas. (Capability unit IIIe–1; woodland group 2; building site group 5)

Storden-Lester loams, 12 to 18 percent slopes, eroded (SlD2).—These are moderately steep soils on irregular, short ridges and knolls. About 65 percent of the unit is Storden loam, and 35 percent is Lester loam. For a description of Lester soils, refer to "Lester Series." Erosion has removed one-third to two-thirds of the original surface layer, and the present plow layer is a mixture of the original surface layer and material from the subsoil. There are many bald spots of yellowish, limy clay loam on the uppermost edges of the steeper slopes.

These soils are very low in organic-matter content and generally have poor tilth. They are fair for crops and moderately good for pasture. The erosion hazard is severe in cultivated areas. (Capability unit IVe–1; woodland group 2; building site group 6)

Talcot Series

The Talcot series consists of silty, very poorly drained, limy soils that are moderately deep over sand and gravel. These soils occupy depressions and drainageways on outwash plains and stream terraces. The most extensive areas in the county are on outwash plains of the South Fork Crow River. The native vegetation consisted of marshgrasses, reeds, and willows.

The surface layer is black, friable silty clay loam. It is about 19 inches thick. This layer contains fine fragments of snail shells and is limy. The upper part is cloddy. The lower part has moderate blocky structure. The subsurface layer is about 4 inches thick. In comparison with the surface layer, it is slightly lighter colored, is more mottled, and has fewer fragments of snail shells. It has weak structure.

The subsoil is dark-gray to light olive-gray, friable silty clay loam mottled with olive. It is about 7 inches thick, is limy, and has weak blocky structure that grades to massive.

The limy underlying material consists of about 6 inches of olive loamy sand over deep, loose sand and gravel.

Natural fertility is moderate. The organic-matter content is high. Runoff is very slow, and the moisture-storage capacity is moderately high. Permeability is moderate in the subsoil and rapid in the underlying material. These soils have a high water table. Unless drained, they are seasonally ponded.

Drained areas are well suited to corn and soybeans. Undrained areas are used mainly for wild hay and pasture.

Typical profile of Talcot silty clay loam (cultivated field; less than 1 percent slope; NE¼NW¼ sec. 29, T. 116 N., R. 26 W.):

Ap—0 to 10 inches, black (N 2/0) silty clay loam; cloddy; friable; many fine fragments of snail shells; calcareous; gradual, wavy boundary.

A11—10 to 19 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure; friable; few fine fragments of snail shells; calcareous; gradual, wavy boundary.

A12—19 to 23 inches, very dark gray (5Y 3/1) silty clay loam; tongues of black (5Y 2/1); few narrow tongues of olive gray (5Y 5/2); few, fine, faint, olive (5Y 5/3) and dark-brown (7.5YR 3/2) mottles; root channels; weak, very fine, subangular blocky structure; friable; few fine fragments of snail shells; calcareous; gradual, wavy boundary.

B2g—23 to 26 inches, dark-gray (5Y 4/1) and gray (5Y 5/1) silty clay loam; tongues of olive gray (5Y 5/2); few, fine, faint, olive (5Y 5/4) mottles; weak, very fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C1g—26 to 30 inches, olive-gray (5Y 5/2) and light olive-gray (5Y 6/2) silty clay loam; few, fine, distinct, light olive-brown (2.5Y 5/6) and pale-olive (5Y 6/4) mottles; massive; friable; calcareous; clear, wavy boundary.

IIC2g—30 to 36 inches, variegated olive (5Y 5/3), olive-gray (5Y 5/2), and pale-olive (5Y 6/3) loamy sand; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; single grain; loose; calcareous.

IIC3g—36 to 50 inches, variegated olive (5Y 5/3 and 5/4), olive-gray (5Y 5/2), yellowish-brown (10YR 5/4), and dark yellowish-brown (10YR 4/4) coarse and very coarse sand and fine gravel; single grain; loose; calcareous.

The Ap horizon is typically silty clay loam, but in spots it is silt loam or clay loam. It ranges from black to very dark gray in color and from 16 to 24 inches in thickness. In places this horizon is covered with a mantle, as much as 12 inches thick, of calcareous muck or peat. In many places the A horizon contains small fragments of snail shells. In places there are layers of loam or sandy clay loam just above the coarse underlying material. The underlying material is within a depth of 24 to 42 inches. In places it is a mixture of sand and fine gravel. In other places it consists of stratified sand, coarse sand, and fine gravel. The entire solum and the underlying material are calcareous.

In comparison with the poorly drained Mayer soils, Talcot soils are finer textured, are more likely to be ponded, have a thicker surface layer, and are more intensively gleyed. Talcot soils are closely associated with the well-drained Wadena soils and the somewhat excessively drained Estherville soils.

Talcot silty clay loam (Ta).—This soil occurs in shallow basins and drainageways. It is 24 to 42 inches thick over gravel and sand. In a few areas there are variable bands of loamy material between the underlying gravelly and sandy layers.

This soil is ideal for wildlife. Undrained areas are fair for wild hay or pasture. Drained areas are good for corn and soybeans, but they are susceptible to frost. The content of lime is a limitation that can be offset by applying large amounts of potash and phosphate. Excess water is a severe limitation. (Capability unit IIIw–1; woodland group 9; building site group 10)

Terril Series

The Terril series consists of deep, loamy, nearly level to rolling, moderately well drained soils that formed in recent colluvium. These soils occur at the base of steeper slopes and in drainageways on the glacial uplands. The native vegetation was grass.

The surface layer is black, friable loam. It is about 39 inches thick, has moderate blocky structure, and is slightly acid.

The underlying material, to a depth of more than 52 inches, is friable to firm clay loam. It is neutral and has blocky structure. The upper part is very dark gray and very dark grayish brown mottled with olive brown. The lower part is dark grayish brown mottled with olive brown.

Natural fertility is high. The organic-matter content is high. Runoff is medium, permeability is moderate, and the moisture-storage capacity is high. The water table is seasonally moderately high. These soils receive sidehill seepage.

Terril soils are well suited to all of the common crops. Generally they occur as narrow, irregular bands and are farmed with the adjacent steeper soils.

Typical profile of Terril loam (alfalfa field; 3 percent slope; SW¼NE¼ sec. 12, T. 116 N., R. 24 W.):

Ap—0 to 8 inches, very dark gray (10YR 3/1) to black (10YR 2/1) loam; moderate, fine, granular structure; friable when moist, slightly plastic when wet; slightly acid.

A11—8 to 18 inches, black (10YR 2/1) loam; moderate, fine, granular structure; friable when moist, slightly plastic when wet; slightly acid.

A12—18 to 39 inches, black (10YR 2/1) loam; moderate, very fine, subangular blocky structure; friable when moist, slightly plastic when wet; slightly acid.

B1—39 to 45 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) clay loam; many, fine, distinct mottles of dark grayish brown (2.5Y 4/2), olive brown (2.5Y 4/4), and light olive brown (2.5Y 5/4); moderate, very fine and fine, subangular blocky structure; friable to firm when moist, slightly plastic and slightly sticky when wet; neutral.

B2—45 to 52 inches, dark grayish-brown (2.5Y 4/2) clay loam; many, fine, distinct mottles of olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4); moderate, very fine and fine, subangular blocky structure; friable to firm when moist, slightly plastic and slightly sticky when wet; neutral.

The A horizon is typically loam, but in spots it is silt loam. It consists of recent overwash material and ranges from 12 to more than 40 inches in thickness. The B horizon ranges from loam to clay loam. The solum and the underlying material are neutral to medium acid. The depth to limy glacial till ranges from 40 to more than 60 inches.

Terril soils have a much thicker surface layer than the moderately well drained LeSueur soils and the well drained Lester and Hayden soils. They are better drained than the poorly drained Webster soils.

Terril loam, 0 to 6 percent slopes (TeB).—This very gently sloping soil occurs at the base of steeper slopes. In a few areas it has a thin layer of sandy material over finer textured overwash.

This soil is very good for crops and pasture. The erosion hazard is moderate. (Capability unit IIe–1; woodland group 1; building site group 8)

Terril loam, 7 to 11 percent slopes (TeC).—This strongly sloping soil occurs at the base of steeper slopes. It has a somewhat thinner layer of overwash than is typical of the series. Areas are generally narrow and irregular.

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This soil is good for crops and pasture. The erosion hazard is severe. (Capability unit IIIe–1; woodland group 2; building site group 8)

Terril loam, occasionally flooded (To).—This soil is on flood plains. Floodwaters do not remain long, nor do they flow rapidly enough to cause cutting and excessive loss of soil. Some areas dissected by many old stream channels have short narrow ridges and appear to be corrugated.

This soil is very good for crops and pasture. Occasional flooding is the most serious limitation. Floods in spring delay planting, and floods in June are likely to destroy crops. (Capability unit IIw–2; woodland group 1; building site group 11)

Wadena Series

The Wadena series consists of loamy, nearly level to rolling, well-drained soils that are moderately deep over limy sand and gravel. These soils are on outwash plains and stream terraces. The native vegetation was prairie grass.

The surface layer is black, friable loam. It is neutral and is about 10 inches thick. In tilled areas the upper part is cloddy. The lower part has weak blocky structure. The subsurface layer is similar to the surface layer, but it is about 3 inches thick and is lighter colored.

The subsoil is about 17 inches thick, is slightly acid, and has weak blocky structure. The upper part is dark-brown to dark grayish-brown, friable loam. The lower part is dark-brown to dark yellowish-brown, friable sandy loam.

The underlying material consists of deep, loose, yellowish and brownish sand and gravel. It is slightly acid or neutral in the uppermost 10 inches. Below this the material is limy.

These soils warm up fairly early in spring and dry out rapidly after a rain. Natural fertility is moderate. The organic-matter content is high. Runoff is medium, permeability is moderately rapid, and the moisture-storage capacity is moderate.

These soils are suited to all of the common crops. Most of the acreage is cultivated.

Typical profile of Wadena loam (cultivated field; 1 percent slope; NE¼NE¼ sec. 32, T. 117 N., R. 26 W.):

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy; friable; neutral; clear, smooth boundary.

A1—8 to 10 inches, black (10YR 2/1) loam; weak, fine and very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A3—10 to 13 inches, very dark gray (10YR 3/1) to very dark brown (10YR 2/2) loam; weak, fine and very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—13 to 17 inches, dark brown (10YR 3/3) to very dark brown (10YR 2/2) loam; weak, fine and very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B22—17 to 20 inches, dark-brown (10YR 4/3) to dark grayish-brown (10YR 4/2) loam; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B23—20 to 24 inches, dark-brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) sandy loam; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B3—24 to 30 inches, dark yellowish-brown (10YR 4/4) and dark-brown (10YR 4/3) coarse sandy loam; very weak, fine, subangular blocky structure; slightly acid; clear, smooth boundary.

C1—30 to 40 inches, variegated dark yellowish-brown (10YR 4/4), dark-brown (10YR 4/3), and yellowish-brown (10YR 5/4) coarse sand and fine gravel; single grain; loose; many small shale fragments; slightly acid or neutral; clear, smooth boundary.

C2—40 to 50 inches, variegated brown (10YR 5/3), yellowish-brown (10YR 5/4), dark yellowish-brown (10YR 4/4), and grayish-brown (10YR 5/2) coarse sand and fine gravel; single grain; loose; calcareous.

Typically, the A horizon is loam. It is neutral or slightly acid. The B horizon is typically loam but ranges to light clay loam and in most places grades to sandy loam just above the underlying coarse-textured material. This horizon is slightly acid or medium acid. The depth to sand and gravel is generally 24 to 30 inches. The sandy and gravelly underlying material is leached in the upper part in places but ordinarily has free lime carbonates within a depth of 48 inches.

Wadena soils are deeper over sand and gravel than the somewhat excessively drained Estherville soils. They have a finer textured, thicker, less deeply leached solum than the somewhat excessively drained Hubbard soils. They differ from the well-drained Fairhaven soils in having a loamy rather than a silty profile. They have a less clayey subsoil than the well-drained Kasota soils.

Wadena loam, 0 to 2 percent slopes (WaA).—This soil is 24 to 36 inches deep over sand and gravel. Included in mapping were spots where the surface is covered with a thin mantle of wind-drifted sandy material. Also included were a few areas where the soil is moderately well drained.

This soil is very good for small grain and pasture and moderately good for corn. It is slightly droughty. (Capability unit IIs–1; woodland group 1; building site group 1)

Wadena loam, 2 to 6 percent slopes (WaB).—This soil is 24 to 30 inches deep over sand and gravel. It has gently undulating, smooth, short slopes. Included in mapping were a few areas where erosion has removed 3 to 6 inches of the original surface layer.

This soil is very good for small grain and pasture and moderately good for corn. It is slightly droughty and is subject to erosion. (Capability unit IIe–4; woodland group 1; building site group 1)

Wadena loam, 6 to 12 percent slopes, eroded (WaC2).—This soil is 22 to 28 inches deep over sand and gravel. It has rolling, fairly even, short slopes. Erosion has removed as much as 6 inches of the original surface layer. The present plow layer is a mixture of the original grayish-brown surface layer and material from the subsoil. The organic-matter content is generally low.

This soil is fairly good for small grain and pasture. It is too droughty for corn in most years. The erosion hazard is severe. (Capability unit IIIe–3; woodland group 2; building site group 2)

Webster Series

The Webster series consists of silty, poorly drained soils that formed in limy glacial till. These soils are on flats and in drainageways in the uplands. The original vegetation was prairie grass.

The surface layer is black, friable silty clay loam. It is about 14 inches thick, is neutral, and has moderate to weak blocky structure.

The subsoil is dark-gray to very dark grayish-brown, friable clay loam. It is about 6 inches thick, is neutral, and has weak blocky structure.

The underlying material is deep, light brownish-gray clay loam mottled with light olive brown and yellowish brown. It is friable, massive, and limy.

Figure 14 shows a profile of Webster silty clay loam.

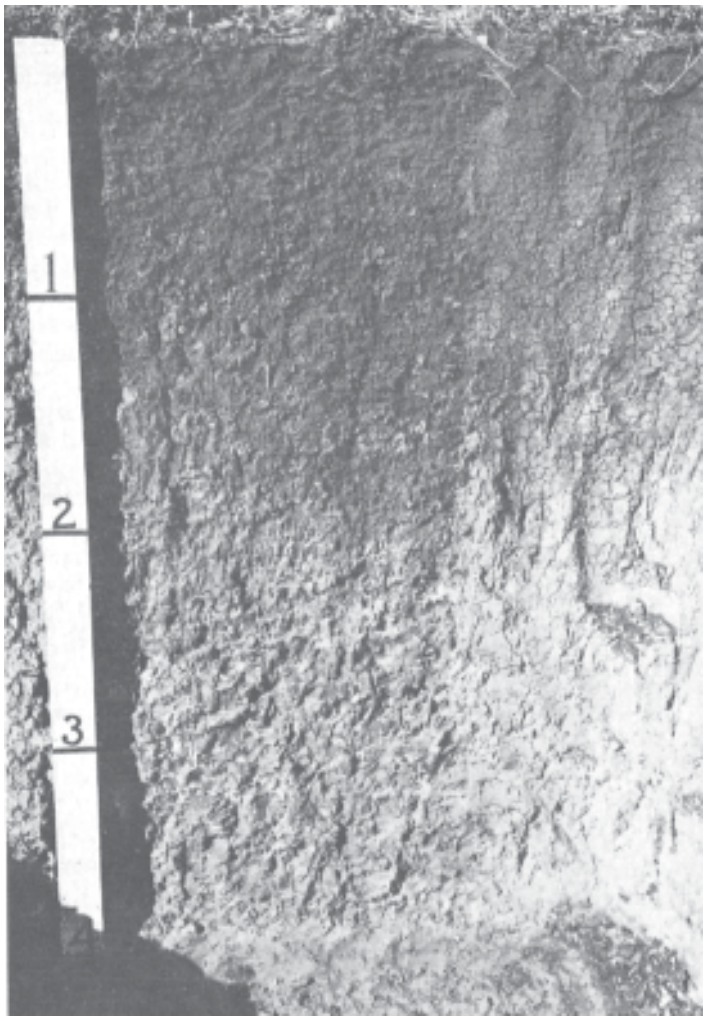

Figure 14.—**Profile of Webster silty clay loam.**

These soils have a fairly high seasonal water table. Runoff is slow, permeability is moderately slow, and the moisture-storage capacity is high. Natural fertility is high. The organic-matter content is high.

Drained areas are well suited to all of the common crops, especially corn and soybeans. Most of the acreage is cultivated, and part is pastured.

In this county Webster soils are mapped only with Cordova soils.

Typical profile of Webster silty clay loam (bluegrass pasture; 1 percent slope; SW¼SE¼ sec. 5, T. 116 N., R. 26 W.):

A11—0 to 10 inches, black (10YR 2/1) silty clay loam; moderate, very fine and fine, subangular blocky structure; friable when moist; slightly plastic and slightly sticky when wet; many roots; high organic-matter content; neutral; clear, smooth boundary.

A12—10 to 14 inches, black (10YR 2/1) silty clay loam; weak to moderate, fine and medium, subangular blocky struc-

ture; friable when moist, slightly plastic and slightly sticky when wet; many roots; neutral; clear, smooth boundary.

Bg—14 to 20 inches, dark-gray to very dark grayish-brown (10YR 4/1 to 3/2) clay loam; weak, medium, subangular blocky structure; friable when moist, slightly plastic and slightly sticky when wet; few roots; neutral; clear, smooth boundary.

C1g—20 to 28 inches, light brownish-gray (2.5Y 6/2) clay loam; common, fine, faint, light olive-brown (2.5Y 5/4) mottles; massive; friable when moist, slightly plastic and slightly sticky when wet; few reddish iron stains; few lime pebbles; slightly calcareous; clear, smooth boundary.

C2g—28 to 36 inches, light brownish-gray (2.5Y 6/2) clay loam; many, fine, distinct, light yellowish-brown (2.5Y 6/4) mottles; massive; friable when moist, slightly plastic and slightly sticky when wet; few reddish iron stains; few lime pebbles; calcareous.

The A horizon is typically silty clay loam, but in spots it is silt loam or clay loam. It is typically 12 to 16 inches in thickness but ranges from 10 to 20 inches. The B horizon is clay loam or silty clay loam. In comparison with the A horizon and the underlying material, it shows little increase in clay content. These soils are typically grayish, have varying degrees of mottling, and either have weak structure or are structureless. The solum is neutral or slightly acid. The depth to free lime carbonates ranges from 18 to 30 inches.

Webster soils differ from the poorly drained Cordova soils in lacking a subsurface layer and in having less development and a lower clay content in the subsoil. They differ in reaction from the poorly drained Canisteo soils, which are calcareous throughout the solum.

Use of Soils for Crops and Pasture

The soils of Carver County vary considerably in their suitability for crops. Corn, oats, and alfalfa are the main crops. Soybeans, sweet corn, seed corn, and peas are important cash crops. Dairying is the principal kind of farming. Raising hogs and beef cattle is important also.

Generally, lime, phosphate, and potash are needed. The amounts to be applied are best determined through soil tests.

Few farms are irrigated. The most likely locations for irrigation systems are on the sandy plains along the Minnesota and Crow Rivers.

The capability classification used by the Soil Conservation Service, in which the soils are grouped according to their suitability for crops, is explained in the pages that follow, and the soils in each capability unit and their suggested use and management are described. At the end of this section is a table that shows predicted yields of specified crops, under two levels of management.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops or to rice and other crops that have special requirements. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils, and without consideration of possible but unlikely major reclamation projects.

In the capability system, all the soils are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I. Soils have few limitations that restrict their use.

Class II. Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils have severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses identified by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding Arabic numerals to the subclass symbol, for example, IIe–4 or IIIe–2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and

the Arabic numeral specifically identifies the capability unit.

Approximately 5 percent of the acreage in this county is in capability class I; 48 percent in class II; 20 percent in class III; 5 percent in class IV; 9 percent in class V; 5 percent in class VI; 7 percent in class VII; and 1 percent in class VIII.

Approximately 57 percent of the acreage is susceptible to erosion, 36 percent is limited by wetness, and 7 percent is limited by droughtiness.

In the following pages each of the capability units in Carver County is described, and suggestions for use and management are given. The names of soil series represented are mentioned in the description of each unit, but this does not mean that all the soils of a given series are in the unit. The capability unit designation for each soil in the county can be found in the "Guide to Mapping Units" at the back of the soil survey.

Capability unit I–1

This unit consists of soils of the LeSueur series and of the Fairhaven series, deep variant. These soils are nearly level, deep, moderately well drained to well drained, and medium textured to moderately fine textured. They have few limitations. Natural fertility is high. The root zone is deep. The moisture-storage capacity is high, and the movement of air and water through the soils is favorable for plant growth.

These soils are well suited to corn and are used intensively for corn and soybeans. They are also well suited to small grain, alfalfa or other hay, and pasture grasses. Corn can be grown year after year if the soils are well managed.

Preserving tilth aids in efficient use of plant nutrients and makes the soil easier to work. It is important to return a large amount of crop residue to the plow layer, either directly or through bedding or grazing, to maintain optimum rates of infiltration and permeability. Adequate fertilization is important also. Tillage should be limited to the amount needed to prepare a seedbed and to control weeds and should be done at the proper moisture content. After fall plowing, the field should be left rough through the winter. Planting corn by the wheel-track method reduces the risk of compaction.

These soils make good pasture if they are adequately fertilized and are seeded to a mixture consisting of alfalfa, bromegrass, and a small amount of orchardgrass. Some parts of the areas now in permanent pasture are wooded or brushy.

Odd areas and the edges of fields can be planted to provide food and cover for wildlife. Honeysuckle, lilac, crabapple, and similar shrubs are suitable. White spruce, white pine, Russian-olive, and redcedar are trees suggested for planting.

Capability unit IIe–1

This unit consists of soils of the LeSueur and Terril series. These soils are gently sloping, deep, moderately well drained, and medium textured to moderately fine textured. Slopes generally are short. Natural fertility is high. The moisture-storage capacity is high.

These soils are well suited to corn, soybeans, small grain, alfalfa or other hay, and pasture grasses.

Controlling erosion and preserving tilth are the main management problems. It is important to return a large amount of crop residue to the soil. Adequate fertilization is important also. Planting row crops by the wheel-track method helps to control erosion and also reduces the risk of compaction.

These soils make good pasture if they are adequately fertilized and are planted to a mixture consisting of alfalfa, bromegrass, and a small amount of orchardgrass. Some parts of the areas now in permanent pasture are wooded or brushy.

Odd areas and the edges of fields can be planted to provide food and cover for wildlife. Honeysuckle, lilac, crabapple, and similar shrubs are suitable. White spruce, white pine, Russian-olive, and redcedar are trees suggested for planting.

Capability unit IIe–2

This unit consists of soils of the Lester series. These soils are gently sloping, deep, well drained, and medium textured. Permeability is moderate, and the moisture-storage capacity is high. Erosion is slight to moderate. The eroded soil has lost one-third to two-thirds of the original surface layer; it has poor tilth and is low in organic-matter content.

The soils of this unit are suited to all of the common crops, including corn, soybeans, small grain, and alfalfa.

Erosion is the principal hazard. If no mechanical means of controlling erosion are used, the crop rotation should consist mainly of close-growing crops. A suitable rotation would consist of a row crop, a small grain, and 1 or 2 years of grass-legume meadow. If erosion is controlled by terracing, contour tillage, and stripcropping, more row crops can be grown. Terracing is the most effective of these practices. Usually the terraces need to be graded. Outlets for the terraces should be constructed and seeded to grass a year before the terraces are built. Minimum tillage and wheel-track planting of row crops reduce the risk of erosion and also the risk of compaction.

Generally these soils require moderate amounts of phosphate and potash. The eroded soil is low in nitrogen and organic-matter content; it would benefit from applications of manure and from the inclusion of legumes in the crop rotation. Crop residue can be utilized to supply organic matter and plant nutrients and to improve tilth.

These soils make good permanent pasture. Well-managed, adequately fertilized pasture of tall grasses and legumes, such as a mixture consisting of alfalfa, bromegrass, and a small amount of orchardgrass, produces more forage than permanent bluegrass pasture. Many pastures produce poor forage because they are wooded, brushy, or overgrazed.

Odd areas and field borders can be planted to conifers, shrubs, legumes, and grasses to provide food and cover for wildlife. White pine, redcedar, and Russian-olive are trees suitable for planting. Suitable shrubs include honeysuckle, lilac, and crabapple.

Capability unit IIe–3

This unit consists of soils of the Hayden series. These soils are gently sloping, deep, well drained, and medium textured. Permeability is moderate, and the moisture-storage capacity is high. The eroded soils have lost one-third to two-thirds of their original surface layer; they have poor tilth and are low in organic-matter content.

These soils are well suited to all of the common crops, including corn, soybeans, small grain, and alfalfa.

Erosion is the principal hazard. Many areas of these soils have complex or irregular slopes that preclude mechanical practices for erosion control. In such areas, the crop rotation should consist largely of close-growing crops. A suitable rotation would include a row crop, a small grain, and 1 or 2 years of grass-legume meadow. The row crop should be planted by the wheel-track method, large amounts of fertilizer should be used, and crop residue should be utilized. More row crops can be grown where terracing, stripcropping, and contour tillage are practical. Terracing is the most effective of these practices. Usually the terraces need to be graded. Outlets should be constructed and seeded to grass a year before the terraces are built.

These soils benefit from an application of lime. Generally they require moderate amounts of phosphate and potash. They require nitrogen if the cropping system includes successive years of corn or of corn and other row crops. An adequate amount of nitrogen usually can be supplied by growing legumes just before the corn crop, but a small amount in the starter fertilizer is advisable. These soils also benefit from applications of manure. Crop residue can be utilized to supply organic matter and plant nutrients and to improve tilth.

These soils are well suited to pasture. Well-managed, adequately fertilized pasture of tall grasses and legumes, such as a mixture consisting of alfalfa, bromegrass, and a small amount of orchardgrass, produces more forage than permanent bluegrass pasture.

Odd areas and field borders can be planted to conifers, shrubs, legumes, and grasses to provide food and cover for wildlife. White spruce, white pine, redcedar, and Russian-olive are trees suitable for planting. Suitable shrubs include honeysuckle, lilac, and crabapple.

Capability unit IIe–4

This unit consists of soils of the Lester-Estherville complex and soils of the Fairhaven, Kasota, and Wadena series. These soils are gently sloping, moderately deep, well drained, and medium textured. In most places they are underlain by sand or gravel, or both, within a depth of 24 to 36 inches. Permeability is moderate, and the moisture-storage capacity is moderate. Erosion is a hazard. The eroded soils have lost one-fourth to three-fourths of their original surface layer; they have poor tilth and are low in organic-matter content.

These soils warm up fairly early in spring and generally are easy to till. They can be plowed either in spring or in fall. They are suited to corn, soybeans, small grain, hay, and pasture grasses.

Erosion is the principal hazard. If no mechanical means of controlling erosion are used, the crop rotation should consist mainly of close-growing crops. A suitable rotation would include grass-legume meadow 2 years in 5. More intensive management, including terraces, waterways, and contour strips, would allow more years of row crops. The uniformity of the depth of the substratum should be checked before terraces are installed. Outlets for terraces should be constructed and seeded to grass a year before installation. Plow planting of row crops reduces the risk of erosion and also the risk of compaction.

These soils generally require moderate amounts of phosphate and potash. They require nitrogen if the cropping system includes successive years of corn or of corn and other row crops. An adequate amount of nitrogen is usually supplied if legumes are grown just before the corn crop, but a small amount in the starter fertilizer is advisable. These soils also benefit from applications of manure.

These soils are fairly good for pasture, but supplemental pasture generally is needed during prolonged dry periods. Well-managed, adequately fertilized pasture of tall grasses and legumes, such as a mixture consisting of alfalfa, bromegrass, and a small amount of orchardgrass, produces more forage than permanent bluegrass pasture. Grazing should be rotated to give plants a chance to recover. Some pastures produce poor forage because they are wooded and brushy.

Odd corners, old gravel pits, and areas adjacent to pits can be developed for wildlife. Winter cover generally is lacking. The plantings should include suitable drought-resistant legumes, grasses, shrubs, and conifers.

Generally these soils are not used for trees. A few areas support poor stands of mixed hardwoods, and these areas are used as pasture.

Capability unit IIw–1

This unit consists of soils of the Biscay, Canisteo, Chaska, Comfrey, Cordova, Mayer, and Webster series. These are poorly drained soils on flats and in depressions. Except for the Biscay and Mayer soils, which are underlain by sand and gravel at a depth of 24 to 42 inches and are moderately permeable, these soils are deep, silty, and moderately slowly permeable. All have a fairly high seasonal water table. Natural fertility is high, as is also the moisture-storage capacity.

Drainage is the most important management need. If tile drainage is planned, Chaska and Comfrey soils should be checked carefully to determine the frequency of flooding before tile is installed. If drained, the soils in this unit are suited to all common crops, especially corn and soybeans. They can be used intensively for row crops.

Good tilth encourages efficient use of plant nutrients, makes it easier to maintain drainage systems, and makes the soil easier to work. It is important to return a large amount of residue to the plow layer, either directly or through bedding or grazing, to maintain optimum rates of infiltration and permeability. Adequate fertilization, minimum tillage, and tillage at the proper moisture content are important also. Fall plowing ordinarily provides a good seedbed in spring. Plowing when the soils are wet is inadvisable because they become compacted and cloddy.

These soils are somewhat wet and cold in spring and consequently need starter fertilizer, including nitrogen, to insure a rapid initial growth of crops. Nitrogen also is needed if the cropping system includes successive years of corn or of corn and other row crops. A meadow crop consisting largely of legumes, grown just before a corn crop, supplies enough nitrogen for the corn.

Most of the soils require moderate amounts of phosphate and potash. Lime ordinarily is not needed. The Canisteo and Mayer soils require no lime but need large amounts of phosphate and potash.

These soils make very good pasture. They hold moisture well throughout the growing season. They are well suited to bluegrass, to a mixture of tall grasses and legumes,

or to a mixture of bromegrass, red clover, and alsike. Grazing should be delayed until the soil becomes firm. These soils are suitable sites for stock-water pits.

Odd areas and field borders can be planted to conifers, shrubs, legumes, and grasses to provide food and cover for wildlife. Red clover and alsike are the best legumes for this use. White spruce, white pine, and redcedar are suitable conifers. Russian-olive is well suited. Suitable shrubs are honeysuckle, lilac, and crabapple.

Some areas of Cordova soils support fairly dense stands of brushy hardwoods, but the rest of the soils in this unit are used mainly for crops.

Capability unit IIw–2

This unit consists of Alluvial land and a soil of the Terril series. Both are loamy, moderately well drained soils on flood plains. They are slightly wet and occasionally flooded. Natural fertility is moderately high to high. The moisture-storage capacity is moderately high to high, and permeability is moderate. Periodic wetness and the risk of flooding are moderate limitations.

If adequately drained and well managed, these soils are well suited to corn and soybeans. They are used for small grain also, but lodging is a hazard during wet periods. Floods in spring are likely to delay planting. Crops grow more slowly on these soils than on the better drained soils. Occasionally, crops are destroyed by floods in June.

Growing sod crops and cover crops occasionally helps to maintain the organic-matter content and preserve tilth. All crop residue should be returned to the soil. Streambanks may need to be stabilized, by planting willow, for example, where streams meet or make sharp turns.

These soils are well suited to pasture. They hold moisture well throughout the growing season. Well-managed pasture of bluegrass or pasture of tall grasses and legumes provides good grazing.

Natural cover and food for wildlife can be planted. Red clover and alsike are the best legumes for planting. White spruce, white pine, and redcedar are suitable conifers. Russian-olive is well suited. Suitable shrubs include honeysuckle, lilac, and crabapple. Small wet areas can be planted to willow and reed canarygrass.

Capability unit IIs–1

This unit consists of soils of the Fairhaven, Kasota, and Wadena series. These are nearly level, well-drained loams and silt loams that are underlain by sand and gravel at a depth of 24 to 36 inches. They warm up early in spring and are easy to till. The soils are slightly droughty. The uppermost 5 feet holds only 6 to 9 inches of water available to plants. Natural fertility is high. Permeability is moderately rapid.

These soils are suited to corn, soybeans, small grain, hay, and pasture grasses. They respond to irrigation. If well managed, they can be farmed intensively to row crops. Corn can be grown year after year.

All residue should be returned to the soil to improve fertility and to increase the moisture-storage capacity. Adequate fertilization and minimum tillage are important. The soils can be plowed either in spring or in fall. If they are spring plowed, plow planting of row crops is advisable because it reduces the risk of compaction and helps to control erosion.

These soils make fairly good pasture, but supplemental pasture is generally needed during prolonged dry periods. Well-managed, adequately fertilized pasture of tall grasses and legumes, such as a mixture of alfalfa, bromegrass, and a small amount of orchardgrass, provides more grazing than permanent bluegrass pasture. Grazing should be rotated to give the plants time to recover. Some pastures produce poor forage because they are wooded or brushy.

Odd corners, old gravel pits, and areas adjacent to the pits can be developed for wildlife. Winter cover generally is lacking. Plantings should include suitable drought-resistant legumes, grasses, shrubs, and conifers.

Generally these soils are not used for trees. A few areas support poor stands of mixed hardwoods, and these areas are used for pasture.

Capability unit IIIe–1

This unit consists of soils of the Lester and Storden series. These soils are moderately sloping, deep, and well drained. Natural fertility is high. The moisture-storage capacity is high, and permeability is moderate. Because of slope, these soils are severely limited by risk of erosion. In cultivated areas, from one-third to two-thirds of the original surface layer has been lost through erosion and the organic-matter content is generally low.

These soils are suited to most of the common crops, including alfalfa and other hay crops and pasture grasses. They are not suited to soybeans, which loosen the surface soil and consequently increase the hazard of erosion.

Crop rotation, fertilization, and residue management are needed, along with mechanical practices, for control of erosion and maintenance of fertility. Terraces, waterways, and contour strips are needed for control of runoff. Contour tillage provides some means of control where stripcropping and terracing are not practical. Plow planting of the row crops is advisable. Terraces allow more years of row crops. Outlets for the terraces should be constructed and seeded to grass a year before the terraces are built. The sides of waterways, and also of gullies, should be shaped, seeded to grass, and then kept permanently in vegetation.

Moderate amounts of phosphate and potash are needed. The eroded soils are low in nitrogen and organic-matter content. They would benefit from applications of manure and from the inclusion of legumes in the crop rotation. Crop residue can be utilized to supply organic matter and plant nutrients and to improve tilth.

These soils are suitable for pasture. Bluegrass or a mixture consisting of alfalfa, bromegrass, and a small amount of orchardgrass makes good permanent pasture. Some pastures are now producing poor forage because they are wooded and brushy. There are suitable sites for impounded ponds.

Conifers, shrubs, legumes, and grasses should be planted to provide food and cover for wildlife. White spruce, white pine, redcedar, and Russian-olive are trees suggested for planting. Suitable shrubs include honeysuckle, lilac, and crabapple.

These soils are suitable for woodland also, but most areas are not protected from fire and grazing.

Capability unit IIIe–2

This unit consists of soils of the Hayden series. These are moderately sloping, deep, well-drained loams. Per-

meability is moderate, and the moisture-storage capacity is moderately high. Natural fertility is moderate. The organic-matter content is very low. Tilth is poor. The erosion hazard is severe. In wooded or pastured areas, the soils are only slightly eroded, but in most cultivated areas they have lost one-third to two-thirds of their original surface layer (fig. 15).

Figure 15.—**Eroded, rolling Hayden loam.**

Except for soybeans, which loosen the surface soil and consequently increase the hazard of erosion, these soils are fairly well suited to the crops commonly grown. They are well suited to alfalfa and other hay crops and pasture grasses.

Crop rotation, fertilization, and residue management are needed, along with mechanical practices, for control of erosion. Many areas of these soils have short, irregular slopes, which make terracing and contour stripcropping impractical. Such areas should be tilled across the slope and cropped in a rotation that includes 3 years of meadow in every 5 years. Contour stripcropping (fig. 16), with alternate strips in meadow, provides adequate control where the terrain is suitable. Terracing, the most effective means of erosion control if the terraces can be adjusted to the slopes, allows more years of row crops in the rotation. Outlets for terraces should be constructed and seeded to grass a year before the terraces are built. Waterways (fig. 17) and gullies should be shaped, seeded to grass, and kept permanently in vegetation. Wheel-track planting of row crops is advisable.

Generally these soils need moderate amounts of phosphate and potash. A heavy application of manure improves tilth and fertility and also reduces the hazard of erosion.

These soils are well suited to pasture. Pasture of tall grasses and legumes, such as a mixture consisting of alfalfa and bromegrass, produces more forage than permanent bluegrass pasture. Bluegrass usually is dormant in midsummer. Grazing should be rotated. Overgrazing and grazing early in spring and late in fall should be avoided. These soils are suitable sites for impounded ponds.

Odd areas and field borders can be planted to provide food and cover for wildlife. Honeysuckle, crabapple, lilac, Russian-olive, and conifers, such as white spruce, white pine, and redcedar, are suitable for planting.

Figure 16.—**Contour strips on Hayden loam, 6 to 12 percent slopes, eroded.**

Figure 17.—**Grass waterways needed on Hayden loam, 6 to 12 percent slopes, eroded.**

Some of these soils support fairly dense, unmanaged stands of hardwoods. Few areas are protected from grazing or fire.

Capability unit IIIe–3

This unit consists of soils of the Lester-Estherville complex and soils of the Fairhaven and Wadena series. These are well-drained, medium-textured, slightly droughty soils that are underlain by sand and gravel within a depth of 24 to 42 inches. The gradient ranges from 6 to 12 percent. Natural fertility is moderately high. Permeability is moderately rapid, and the moisture-storage capacity is moderate. The erosion hazard is severe. In wooded or pastured areas, the soils are only slightly eroded, but in most cultivated areas they have lost one-third to two-thirds of their original surface layer. Generally the eroded soils are low in organic-matter content.

These soils are easy to till. They are suitable for general crops, including alfalfa and other hay crops and pasture grasses, but they should not be used for row crops unless

mechanical practices are used to control erosion. A soybean crop, particularly, increases the hazard of erosion because it loosens the surface soil.

Erosion is the principal hazard. If mechanical practices are not practical and contour tillage is the only means of erosion control, the crop rotation should consist mainly of close-growing crops. A 5-year rotation that includes 3 years of grass-legume meadow would be appropriate. Terraces and strip crops are needed. Strip crops are effective for erosion control because the alternate meadow strips help to control runoff. Terraces are effective in controlling erosion and allow more years of row crops. The uniformity of the depth of the substratum should be checked before terraces are installed. Outlets for terraces should be constructed and seeded to grass a year before installation. The sides of the waterways, and also of gullies, should be shaped, seeded to grass, and then kept permanently in vegetation. Gullies are difficult to control because these soils are only moderately deep over sand and gravel. Plow planting of row crops is advisable.

Generally these soils require moderate amounts of phosphate and potash. Most of them are low in nitrogen. They benefit from applications of manure. Crop residue can be utilized to supply plant nutrients and to improve tilth.

These soils make good pasture in spring and early in summer but generally do not produce the forage needed in midsummer. Pasture of alfalfa and bromegrass provides more grazing than permanent bluegrass pasture. Some pastures need to be cleared of trees, brush, and weeds.

Odd corners, old gravel pits, and areas adjacent to the pits can be developed for wildlife. Winter cover generally is lacking. Plantings should include suitable drought-resistant legumes, grasses, shrubs, and conifers.

Generally these soils are not used for trees.

Capability unit IIIe–4

This unit consists of Dakota and Rasset sandy loams and soils of the Hubbard and Kasota series. These are excessively drained soils that are shallow to moderately deep over sand. The gradient ranges from 2 to 6 percent. The moisture-storage capacity is low, and permeability is moderately rapid. Natural fertility is moderate. The erosion hazard is severe. The eroded soils have lost one-third to two-thirds of their original surface layer. Generally they are low in organic-matter content.

These soils warm up early in spring and are easy to till. They respond well to fertilization and irrigation. They are suitable for all of the common crops if the supply of moisture is adequate.

Wind and water erosion are the principal hazards. Contour stripcropping, with alternate strips in grass-legume meadow, is the most effective means of erosion control. Level terraces are suitable in most places. The substratum should be checked before terraces are constructed. Diversions are needed on some of the long slopes. Spring plowing is advisable. Leaving the fields rough between crops, planting cover crops, or utilizing crop residue improves the moisture-storage capacity of these soils and reduces the risk of erosion.

Ordinarily these soils require lime and moderately large amounts of phosphate and potash. The eroded soils are low in organic-matter content and generally are low in nitrogen. They would benefit from applications of manure and from the inclusion of legumes in the crop rotation.

These soils make good permanent pasture in spring and early in summer but generally do not produce the forage needed in midsummer. Pasturing the meadow in the rotation is better than maintaining permanent pasture. Pasture of alfalfa and bromegrass produces more forage than permanent bluegrass pasture. Rotation of grazing is essential.

Odd corners and areas adjacent to gravel pits can be developed for wildlife. Cover generally is lacking. The plantings should include drought-resistant conifers, shrubs, grasses, and legumes. Clover and birdsfoot trefoil can be planted to provide food for deer and nesting cover for pheasants.

These soils are suitable for conifers, but few areas are wooded.

Capability unit IIIe–5

This unit consists of soils of the Burnsville-Hayden complex and soils of the Estherville series. These are somewhat excessively drained sandy loams and loams that are shallow over sand and gravel. The gradient ranges from 2 to 6 percent. Permeability is moderately rapid, and the moisture-storage capacity is low. Natural fertility is moderate to moderately low. The erosion hazard is moderate. The eroded soils have lost one-third to two-thirds of their original surface layer. Generally they are low in organic-matter content.

These soils warm up early in spring and respond well to fertilization and irrigation. Except for Burnsville soils, which in places have stones and large boulders on the surface and throughout the profile, these soils are easy to till. They are fairly good for small grain but are too droughty to be suitable for corn. They are suitable for alfalfa and other hay crops and pasture grasses.

Spring plowing is advisable. The protective cover of stubble or grass is needed to control erosion in winter. It is important to return all crop residue. Minimum tillage is important also. Many areas are suitable for contour strips. The alternate meadow strips are effective in controlling runoff. Generally terraces are impractical because the soils are shallow over gravel and sand. Contour tillage is advisable where stripcropping is impractical. With contour tillage, a 5-year rotation that includes 2 years of meadow is appropriate. In places diversions are needed on long slopes. Areas in which water concentrates need to be shaped and then seeded to grass to prevent gullying.

These soils require moderately large amounts of phosphate and potash. The moderately eroded soils, which are low in organic-matter content and generally low in nitrogen, are improved by applying manure and by growing legumes and grasses in the crop rotation.

These soils make good pasture in spring and early in summer but generally do not produce the forage needed in midsummer. Consequently, supplemental pasture is needed. Pasturing the meadow in the rotation is better than maintaining permanent pasture. Pasture of alfalfa and bromegrass produces more forage than permanent bluegrass pasture. Rotation of grazing is essential.

Odd corners and areas adjacent to gravel pits can be developed for wildlife, as other cover generally is lacking. The plantings should include drought-resistant conifers, shrubs, legumes, and grasses. Clover and birdsfoot trefoil can be planted to provide food for deer and nesting cover for pheasants.

All of these soils are well suited to conifers. There are brushy hardwoods in some pastures on Burnsville soils.

Capability unit IIIw–1

This unit consists of soils of the Canisteo, Glencoe, and Talcot series. These are very poorly drained soils in depressions and drainageways. Except for Talcot silty clay loam, which is underlain by sand and gravel within a depth of 24 to 42 inches, these soils are deep and silty. The moisture-storage capacity is high, and permeability is moderately slow. Natural fertility is high.

Excess water is a severe limitation, and preserving tilth is a continuing problem. Drainage is essential if these soils are to be cropped (fig. 18). Tile is preferable if outlets are available. Open ditches are needed if large quantities of water must be removed.

Figure 18.—**Corn crop on ponded Glencoe soils.**

If adequately drained, these soils are suited to corn, soybeans, red clover, alsike clover, Ladino clover, bromegrass, and timothy. It is advisable to plant early maturing varieties of corn and soybeans because of the frost hazard. Oats can be grown in drained areas, but lodging is a serious problem. These soils are not suitable for alfalfa.

A 6-year crop rotation that includes 1 year of grass-legume meadow increases the efficiency of the drainage system and helps to preserve tilth and improve fertility. If the soils are well managed, corn can be grown year after year. It is important to return all crop residue, either directly or through bedding and grazing. Fertilization is important also.

Generally these soils require moderate amounts of phosphate. The Glencoe soil requires moderate amounts of potash, but the Talcot soil and Canisteo silty clay loam, depressional, are calcareous and require large amounts of potash to offset the effect of the lime. All of these soils warm up slowly in spring; consequently, starter fertilizer that contains nitrogen is needed to insure rapid initial growth of crops.

Undrained pastures can be improved by plowing early in fall when the soils are dry enough to be worked. It is advisable to seed grasses, such as reed canarygrass, in fall. Grazing should be deferred until the ground is firm. These soils generally make good sites for stock-water pits.

Most undrained areas are marshy and seasonally ponded and are ideal for ducks, pheasants, and muskrats. Shallow pits and level ditches would improve these areas as wildlife habitat. Ditchbanks, as well as the edges of stock-water pits, could be seeded to grasses and legumes to furnish food and cover for wildlife. To protect wildlife during the nesting season, grazing or mowing of the ditchbanks should be delayed until after the middle of July.

These soils are not generally suitable for trees. In many areas there is a sparse growth of willow and alder.

Capability unit IIIw–2

This unit consists of Peat and muck. These soils are severely limited by wetness. The moisture-storage capacity is high. Natural fertility is low.

These soils warm up slowly in spring. In undrained areas they are used for pasture or wild hay or as habitat for wildlife. In drained areas they generally are farmed intensively to corn and soybeans. They are well suited to these crops and are also well suited to potatoes, onions, and other vegetables, and to small grain, alsike clover, and timothy. Lodging is a serious problem if small grain is grown. Because of the frost hazard, only early maturing varieties of crops should be planted.

If these soils are drained, open ditches generally are used as outlets and tile is used for the lateral lines that lead to the ditches. The tile should be installed deep enough to be effective after the soils have settled 18 to 24 inches. Adequate controls are needed to keep the soils from becoming too dry. Dry organic soils can be seriously damaged by fire.

Row crops can be grown year after year if the soils are fertilized and adequately drained, but an occasional grass-legume crop replenishes the supply of organic matter. A cover crop of winter rye is beneficial and protects the soils against wind erosion. An application of manure immediately after the soils are drained promotes decay of the organic matter to a form that is readily used by crops.

These soils generally require large amounts of phosphate and potash. Starter fertilizer that contains nitrogen is needed to insure rapid initial growth of crops.

Undrained areas are suitable for pasture if they are worked during a dry season and then limed and fertilized and seeded to reed canarygrass. When well established, reed canarygrass forms a tough, dense sod that supports grazing animals and haying equipment, even when the soils are partly wet. It is more palatable as hay than wild marsh grass. These soils, particularly Peat and muck, moderately shallow, over loam, make good sites for stock-water pits (fig. 19).

Undrained areas provide ideal habitat for wildlife. Marshy areas can be improved as wildlife habitat by digging level ditches or by installing structures that control the water level.

Peat and muck soils are unsuitable for woodland. Many undrained areas support a poor growth of willow, tamarack, or brush.

Capability unit IIIs–1

This unit consists of Dakota and Rasset sandy loams and soils of the Hubbard and Kasota series. These are nearly level, somewhat excessively drained soils that are

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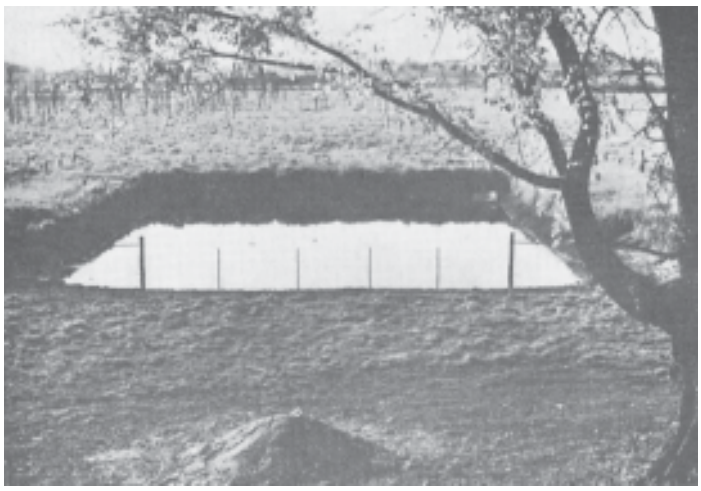

Figure 19.—**Stock-water pit in Peat and muck, moderately shallow, over loam. Pit is fenced and marked, and ramp approach is sanded.**

shallow to moderately deep over sand. The moisture-storage capacity is low; only 3 to 6 inches of water is available to plants within a depth of 5 feet. Permeability is moderately rapid. Natural fertility is moderate. Wind erosion is a hazard.

These soils warm up early in spring and are easy to till. They respond well to fertilization and irrigation. They are suited to all of the common crops if rainfall is adequate throughout the growing season.

Spring plowing is advisable. The protective cover of grass or stubble is needed to control wind erosion in winter. Leaving fields rough between crops or planting cover crops conserves moisture and reduces the hazard of wind erosion. Suitable crop rotations, residue management, stubble mulching, and minimum tillage are important also. Wind stripcropping and a 4-year rotation that includes 1 year of grass-legume meadow are effective in controlling erosion if enough residue is left on the surface.

Generally these soils require moderately large amounts of phosphate and potash. The eroded soils, which are low in organic-matter content and in nitrogen, can be improved by applying manure and growing grasses and legumes in the crop rotation.

Pasturing the meadow in the rotation is better than maintaining permanent pasture. These soils make good pasture in spring and early in summer but do not produce the forage needed in midsummer. Pasture of alfalfa and bromegrass produces more forage than permanent bluegrass pasture.

Odd corners and areas adjacent to gravel pits can be developed for wildlife. Cover generally is lacking. The plantings should include drought-resistant conifers, shrubs, legumes, and grasses. Clover and birdsfoot trefoil can be planted to provide food for deer and nesting cover for pheasants.

These soils are well suited to conifers, but few areas are wooded.

Capability unit IIIs–2

This unit consists of soils of the Estherville series. These are loamy, nearly level, somewhat excessively drained soils that are shallow over sand and gravel. The moisture-storage capacity is low; only 3 to 6 inches of water is available to plants within a depth of 5 feet. Permeability is moderately rapid. Natural fertility is moderate to moderately low. Root penetration is difficult below a depth of 24 inches. Wind erosion is a hazard.

These soils warm up early in spring and are easy to till. They respond well to fertilization and irrigation. They are fairly good for small grain but are too droughty to be suitable for corn.

Spring plowing is advisable. The protective cover of stubble or grass is needed to control erosion in winter. It is important to return all crop residue in order to conserve moisture, improve fertility, and control erosion. Minimum tillage is important also. Wind stripcropping and a 4-year rotation that includes 1 year of grass-legume meadow are effective in controlling erosion if enough residue is left on the surface.

Generally these soils require moderately large amounts of phosphate and potash. Grasses and legumes in the crop rotation and a heavy application of manure improve fertility and increase the moisture-storage capacity.

These soils make good pasture in spring and early in summer but do not produce the forage needed in midsummer. Pasturing the meadow in the rotation is better than maintaining permanent pasture. Pasture of alfalfa and bromegrass produces more forage than permanent bluegrass pasture.

Odd corners and areas adjacent to gravel pits can be developed for wildlife. Cover generally is lacking. The plantings should include drought-resistant conifers, shrubs, legumes, and grasses. Clover and birdsfoot trefoil can be planted to provide food for deer and nesting cover for pheasants.

These soils are well suited to conifers, but few areas are wooded.

Capability unit IVe–1

This unit consists of Storden-Lester loams and soils of the Hayden and Lester series. These soils are moderately steep, deep, well drained, and medium textured to moderately fine textured. Permeability is moderate, and the moisture-storage capacity is moderately high. Fertility is moderate. The organic-matter content ranges from medium to very low. Runoff is rapid, and the erosion hazard is severe. Erosion has been only slight in pastured and wooded areas, but it has removed one-third to two-thirds of the original surface layer in cultivated areas, and nearly all of it in the steeper areas. The severely eroded soils generally have very poor tilth.

The risk of erosion severely limits the use of these soils for crops. Alfalfa is well suited. Cultivated crops can be grown only occasionally. Soybeans loosen the surface soil and increase the erosion hazard.

Contour strips are the most effective means of controlling erosion. The alternate meadow strips help to control runoff. With contour strips, a 5-year rotation that includes 3 years of alfalfa-bromegrass meadow is appropriate. These soils are too steep to be suitable for terraces. Contour tillage is advisable on short, irregular slopes where stripcropping is impractical. With contour tillage, a 4-year rotation that includes 3 years of meadow is appropriate. No row crops should be grown. Waterways should be established and maintained wherever needed. Gullies need to

be shaped and then seeded to grass. In places engineering structures are needed to stabilize gullies enough that grass can be established.

If these soils are to be kept in hay for more than 2 years, they require applications of phosphate and potash after the first cutting in the second year. Manure is beneficial also. An extra heavy application of manure is needed on the severely eroded soils to improve tilth and fertility.

If fertilized and otherwise well managed, these soils make good permanent pasture. Pasture of alfalfa and bromegrass produces more forage than bluegrass pasture. Overgrazing increases the risk of erosion. Many pastures produce poor forage because they are wooded and brushy.

Odd areas can be planted to trees, shrubs, grasses, and legumes, and used as wildlife habitat.

All of these soils are well suited to conifers. Many areas are wooded.

Capability unit IVe–2

The one soil in this unit, Hubbard sandy loam, 6 to 12 percent slopes, eroded, is somewhat excessively drained. It is underlain by sand within a depth of 24 inches. The moisture-storage capacity is low, and permeability is moderately rapid. Natural fertility is moderate. Erosion is a hazard. In cultivated areas erosion has removed one-third to two-thirds of the original surface layer. Generally this eroded soil is low in organic-matter content.

Droughtiness and the risk of erosion are severe limitations. This soil warms up early in spring, is easy to till, and responds well to fertilization. If the supply of moisture is adequate, it is fairly good for some crops. It is well suited to small grain but is too droughty to be suited to corn. Soybeans loosen the surface soil and increase the risk of erosion. Early maturing, drought-resistant varieties of crops should be planted.

Terraces, contour strips, and waterways help to control runoff and erosion. If none of these are used, the rotation should consist largely of close-growing crops. A 5-year rotation that includes 3 years of meadow is appropriate. Terraces allow more years of row crops. The nature of the substratum needs to be checked before terraces are built. Level terraces are usually possible. Contour strips, with alternate strips in meadow, reduce the amount of runoff. Diversions are needed on some of the longer slopes. Green-manure crops and crop residue should be plowed under in spring. All crop residue should be utilized. Cover crops and minimum tillage are important. Plow planting of row crops is advisable.

This soil generally requires lime and moderately large amounts of phosphate and potash. It is low in organic-matter content and in nitrogen. A heavy application of manure and a rotation that includes grasses and legumes are beneficial.

Pasturing the meadow in the rotation is advisable. Pasture of alfalfa and bromegrass produces more forage than native bluegrass pasture.

Odd tracts can be developed for wildlife. Cover generally is lacking. The plantings should include Colorado spruce, white spruce, redcedar, Russian-olive, and caragana. Small areas planted to an alfalfa-bromegrass mixture provide good nesting cover.

This soil is well suited to conifers.

Capability unit IVe–3

This unit consists of soils of the Burnsville-Hayden complex and a soil of the Estherville series. These are sandy loams and loams that are shallow and somewhat excessively drained and are underlain by sand and gravel. The gradient ranges from 6 to 12 percent. Permeability is moderately rapid, and the moisture-storage capacity is low. Natural fertility is moderate to moderately low. Erosion is a hazard. In most cultivated areas it has removed one-third to two-thirds of the original surface layer. Generally the eroded soils are low in organic-matter content.

Droughtiness and the risk of erosion are severe limitations. These soils warm up early in spring and respond well to fertilization. The Estherville soil is easy to till, but the soils of the Burnsville-Hayden complex contain large stones and boulders. These soils are suitable for crops occasionally. They are well suited to early maturing varieties and to winter grain. Soybeans loosen the surface soil and increase the erosion hazard.

Spring plowing is advisable. If plowed in fall, the soils are exposed to erosion throughout the winter. Plow planting or wheel-track planting of row crops, minimum tillage, and the use of cover crops help to conserve moisture and to protect the soil against erosion. Returning all crop residue is important. Contour strips, with alternate strips in meadow, help to control runoff. Terraces generally are impractical because the soils are shallow over sand and gravel. Diversions are needed on some of the long slopes. Waterways should be established and maintained wherever needed. The sides of waterways and gullies should be shaped, seeded to grass, and then kept permanently in vegetation. In some areas engineering structures are needed to stabilize gullies enough that grass can be established. Where the slopes are so irregular and uneven that erosion control practices are impractical, the soils should be kept in close-growing crops most of the time.

These soils require moderately large amounts of phosphate and potash. The eroded soils, which are low in organic-matter content and in nitrogen, benefit from heavy applications of manure and rotations that include grasses and legumes.

These soils make fairly good pasture in spring and early in summer but do not produce the forage needed in midsummer. Pasturing the meadow in the rotation is better than maintaining permanent pasture. Pasture of alfalfa and bromegrass is more drought resistant and produces more forage than bluegrass pasture. Many areas of the Burnsville-Hayden soils make poor pasture because they are wooded and brushy. Overgrazing should be avoided.

Odd areas and gravel pits can be developed for wildlife. The plantings should include drought-resistant trees, shrubs, legumes, and grasses. Colorado spruce, white spruce, and redcedar are conifers suggested for planting. Russian-olive is well suited. Caragana is a suitable shrub.

These soils are suitable for trees, especially conifers.

Capability unit IVs–1

This unit consists of Sandy colluvial land and soils of the Hubbard and Rasset series. These are loamy sands that are nearly level to gently sloping and excessively drained. Permeability is rapid. Natural fertility is low. The moisture-storage capacity is low to very low. In all but the Rasset soils, no more than 3 to 6 inches of water

is available to plants within a depth of 5 feet. The Rasset soils retain moisture somewhat better than the other soils in this unit. Generally the hazard of wind erosion is severe.

These soils warm up early in spring and are easy to cultivate. If the supply of moisture is adequate, they respond well to fertilization. They are well suited to winter grain, short-season crops, and melons. They are not suited to corn and soybeans. If irrigated and otherwise well managed, they are suited to truck crops.

Droughtiness and wind erosion are serious limitations. A cropping system that provides year-round cover is needed. Spring plowing, minimum tillage, crop residue management, wind stripcropping, stubble mulching, and shelterbelts of pine are important for control of wind erosion. With wind stripcropping, the nearly level soils can be cropped in a 6-year rotation that includes 1 or 2 years of grass-legume meadow. Contour strips are effective in the more sloping areas. The alternate strips of meadow help to control runoff. Generally terraces are not used. Waterways should be established and maintained wherever needed.

These soils generally require large amounts of potash and moderate amounts of phosphate. All are low in organic-matter content. Heavy applications of manure and rotations that include grasses and legumes are beneficial.

These soils make poor permanent pasture because it is difficult to maintain a good sod. Pasturing the second year of meadow in the rotation is better than maintaining permanent pasture. Pasture of alfalfa and bromegrass is more drought resistant and produces more forage than bluegrass pasture. There are tracts of pastured brushy woodland on the Rasset soils. If pasture is needed, it would be advisable to clear these tracts and use them for rotation crops and pasture.

Odd areas where winter cover is lacking can be developed for wildlife. The plantings should include drought-resistant conifers, shrubs, legumes, and grasses. In areas where winter cover is adequate, corn or small grain should be left after harvest or should be planted to provide food for pheasants.

All of these soils are well suited to conifers.

Capability unit Vw–1

This unit consists of Peat and muck, moderately shallow, over sand. The sand is within a depth of 42 inches. Natural fertility is low. Frost is a hazard. Fire is a serious hazard because it exposes the generally sterile underlying sand.

These soils are too wet to be suitable for crops. Most areas are in wild hay or pasture. Drainage generally is impractical. Shallow surface ditches can be used, but tile is not suitable. Pastures can be improved if the soils are worked thoroughly during a dry period and then fertilized and seeded with reed canarygrass. When well established, this grass forms a tough, dense sod that supports light haying equipment and grazing cattle even when the soils are wet. Canarygrass is more palatable as hay than wild marsh grass. Its quality and palatability can be improved if it is topdressed with fertilizer.

Most areas provide good cover for wildlife. In many areas shallow pits can be constructed to provide open water for waterfowl.

These soils are too wet to be suitable for trees.

Capability unit VIe–1

This unit consists of eroded and severely eroded soils of the Hayden series. These soils are moderately steep, deep, well drained, and medium textured to moderately fine textured. Permeability is moderate, and the moisture-storage capacity is moderately high. Natural fertility is moderate. The organic-matter content is medium to very low. Runoff is rapid, and the erosion hazard is severe.

These soils are suited to hay crops and pasture grasses, but they are not suited to cultivated crops. Generally they have free lime carbonate within a depth of 36 inches and consequently are well suited to legumes, such as alfalfa. Wooded or pastured areas should not be cleared, and areas now cultivated should be established in permanent vegetation. Plowing, if needed, should be done in spring. Gullies need to be shaped and then seeded to grass (fig. 20). Some have to be stabilized with engineering structures before grass can be established.

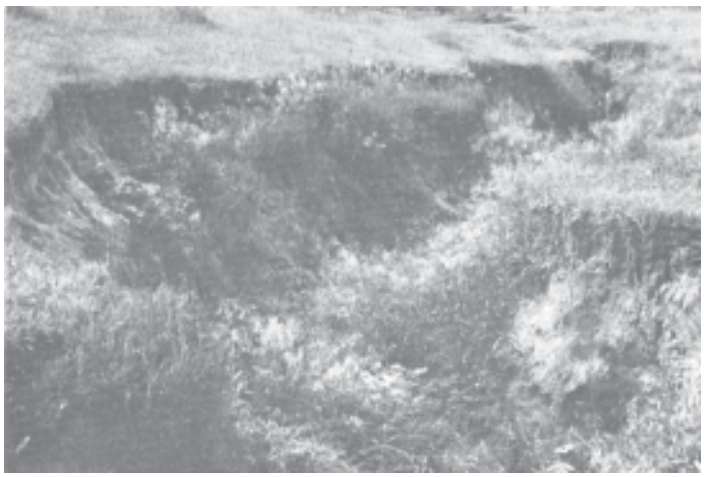

***Figure 20.*—Deep gully in Hayden loam, 18 to 25 percent slopes, eroded.**

Pasture of alfalfa and bromegrass produces more forage than bluegrass pasture. Grazing must be controlled. Fertilization with manure and phosphate or with a commercial mixture of nitrogen, phosphate, and potash is advisable. In places lime is beneficial. Pastures and hay meadows can be improved by renovating and reseeding. The old sod should be disked or dug up and then left on the surface to protect the soils against erosion until the new seedlings emerge. The areas should be seeded to oats and suitable grasses and legumes. The oats can be clipped or pastured or harvested for grain.

Areas of these soils can be developed for wildlife. Plantings should include white spruce, red pine, white pine, redcedar, Russian-olive, honeysuckle, lilac, caragana, legumes, and grasses.

Trees can be planted to improve the existing woodland or to convert to woodland the acreages that are now in pasture and cultivated crops.

Capability unit VIe–2

This unit consists of Burnsville-Hayden sandy loams and soils of the Estherville and Hubbard series. These soils are moderately steep and somewhat excessively drained.

The Burnsville-Hayden sandy loams contain large stones and boulders and are shallow to deep over sand and gravel. The rest of the soils are underlain by sand or gravel, or both, within a depth of 24 inches. All are droughty. The moisture-storage capacity is low, and permeability is moderately rapid. Natural fertility is moderate to low. The erosion hazard is severe. In cultivated areas where the gradient is 12 to 18 percent, erosion has removed one-third to two-thirds of the original surface layer. Generally these eroded soils are very low in organic-matter content.

These soils are suitable for hay crops and pasture grasses, but they are too droughty and too erodible to be used for cultivated crops. The areas now cultivated should be in permanent vegetation.

Maintaining the sod in pasture or meadow is most important. Pasture of alfalfa and bromegrass is more drought resistant and produces more forage than bluegrass pasture. Normally, bluegrass makes little growth in midsummer. Gullies need to be shaped and then seeded to grass. Some have to be stabilized by engineering structures before grass can be established.

White pine, red pine, redcedar, Russian-olive, honeysuckle, lilac, caragana, legumes, and grasses are suitable for planting to provide shelter for wildlife.

Trees can be planted to improve the existing woodland or to convert to woodland the acreages that are now in pasture or in cultivated crops.

Capability unit VIw–1

The unit consists of Alluvial land, frequently flooded, and a soil of the Comfrey series. Both are on flood plains, are frequently flooded, and in most places are poorly drained to very poorly drained. In old stream channels these soils are seasonally ponded or very wet throughout the year. On the slightly elevated ridges and mounds between the channels, they are more sandy and are better drained.

These soils are too wet and too frequently flooded to be suitable for cultivated crops. A row crop can be grown occasionally on the drier soils. Draining the wet soils is not practical as long as the flood hazard exists, and protection against flooding is costly.

The better drained soils make good pasture if cleared and otherwise well managed. Pastures need to be renovated and reseeded occasionally, particularly when infertile sediments bury the sod. They should be seeded to grasses and legumes that tolerate wetness. Oats, if used as a companion crop, should be clipped or pastured. Otherwise, the oats are likely to lodge and to kill the new seedlings.

Pastures in the poorly drained to very poorly drained areas are difficult to renovate. They should be seeded to reed canarygrass or other water-tolerant species. Reed canarygrass should be seeded on frozen ground, either in fall or in spring. Pasture should not be grazed early in spring or after overflow because of the danger of trampling the turf. Stabilizing streambanks keeps streams from cutting into cropland and pasture at sharp turns.

Wildlife is abundant. The marsh hay, cattails, and wet sedges provide excellent cover and nesting. Plantings should include water-tolerant conifers, shrubs, hedges, and grasses.

Many of these areas on the flood plain are brushy, pastured, and wooded.

Capability unit VIs–1

This unit consists of soils of the Hubbard and Rasset series. These are loamy sands that are moderately sloping and excessively drained. The moisture-storage capacity is low to very low. The Rasset soils retain moisture somewhat better than the Hubbard soils. Permeability is rapid. Natural fertility is low to very low. The erosion hazard is severe.

These soils are too droughty and too erodible to be suitable for cultivated crops. The areas now cultivated should be in permanent vegetation.

These soils are suitable for hay crops and pasture grasses. Maintaining the sod in pasture or hay meadow is most important. Pasture of alfalfa and bromegrass is more drought resistant and produces more forage than native bluegrass pasture. Normally, bluegrass makes little growth in midsummer. Gullies should be shaped and then seeded to grass. Some have to be stabilized with engineering structures before grass can be established.

Plantings to provide shelter for wildlife should include white pine, red pine, redcedar, Russian-olive, honeysuckle, lilac, caragana, legumes, and grasses.

Trees can be planted to improve existing woodland or to convert to woodland the acreages that are now in cultivated crops and pasture.

Capability unit VIIe–1

This unit consists of soils of the Hayden series. These soils are steep to very steep, deep, well drained, and medium textured to moderately fine textured. Permeability is moderate. The moisture-storage capacity is moderately high. Runoff is very rapid, and the erosion hazard is very severe.

These soils are not suitable for cultivated crops. Areas now cultivated should be established in permanent vegetation, and wooded or pastured areas should not be cleared.

These soils can be used for hay crops and pasture. Maintaining a good cover of vegetation is most important. Control of grazing is essential. Gullies should be shaped and then seeded to grass. Some have to be stabilized with engineering structures before grass can be established.

Plantings to provide food and shelter for wildlife should include white spruce, red pine, white pine, redcedar, Russian-olive, honeysuckle, lilac, caragana, legumes, and grasses.

These soils are well suited to trees.

Capability unit VIIe–2

This unit consists of Burnsville-Hayden sandy loams and a soil of the Estherville series. These soils are moderately steep to steep and somewhat excessively drained. The Burnsville-Hayden soils are cobbly and stony and are shallow to deep. The Estherville soil is underlain by sand and gravel within a depth of 24 inches. All are droughty. The moisture-storage capacity is low, and permeability is moderately rapid. Natural fertility is low. The erosion hazard is very severe.

These soils are too droughty and too severely eroded to be suitable for cultivated crops. They can be used for hay crops and pasture, but it is difficult to maintain a good vegetative cover.

If the soils are pastured, it is most important to prevent overgrazing. In many areas there is only a sparse growth of vegetation. Pastures are difficult to renovate and reseed.

Gullies should be shaped and then seeded to grass. Some have to be stabilized with engineering structures before grass can be established.

Plantings to provide shelter for wildlife should include conifers, shrubs, grasses, and legumes that are drought tolerant and suitable for shallow soils. These soils are well suited to conifers.

Capability unit VIIs–1

This unit consists of Sandy lake beaches and soils of the Hubbard, Rasset, and Salida series. These soils are sandy and, except for Sandy lake beaches, are moderately steep to steep. The moisture-storage capacity is very low, and permeability is rapid. Natural fertility is very low.

These soils are too droughty and too highly susceptible to erosion to be suitable for cultivated crops.

Generally these soils make poor pasture. If they are to be used as pasture, they should be seeded to a drought-resistant grass, such as bromegrass. Maintaining a permanent sod is difficult. Pasture of alfalfa and bromegrass is more drought resistant and produces more forage than bluegrass pasture. Control of grazing is essential. Gullies need to be shaped and then seeded to grass. Some have to be stabilized with engineering structures (fig. 21) before grass can be established.

***Figure 21.*—Trees and diversion dikes controlling gullies on Salida loamy sand, 18 to 40 percent slopes.**

These soils can be developed for wildlife by planting drought-resistant conifers, shrubs, legumes, and grasses.

Trees can be planted to improve existing woodland or to convert to woodland the acreages that now are idle or in crops or pasture. These soils are well suited to conifers.

Capability unit VIIIw–1

Marsh, the one soil in this unit, occupies the edges of lakes, shallow basins, and ponds. The water level fluctuates, depending on the season. The vegetation consists of cattails, rushes, sedges, willows, and other water-tolerant plants.

This soil is too wet to be suitable for cultivated crops or pasture. During prolonged dry periods, wild hay can be cut from the edges of the marsh.

Marsh provides ideal habitat for waterfowl, muskrat, mink, and upland game. The habitat can be improved by constructing level ditches or by controlling the water level.

Marsh is not suitable for trees.

Predicted Yields of Crops

Table 2 shows predicted yields, under two levels of management, for the principal crops grown in Carver County. Yields in columns A are those to be expected under average management. Yields in columns B are those to be expected under improved management.

The predictions represent the average for a period of 10 years. They are based on interviews with farmers and on records and observations of technicians of the Soil Conservation Service, the Extension Service, and the University of Minnesota Institute of Agriculture. The prevailing climate, the characteristics of the soils, and the results of different kinds of management were among the factors considered.

Under average management, there are few or no erosion control measures. The rotation consists mainly of cultivated crops. Frequently, corn is grown in alternate years with oats and soybeans. Legume meadow is grown 2 years in 6. All available manure and the equivalent of 100 to 150 pounds of starter fertilizer are applied to corn. Little or no fertilizer is applied to small grain or hay. The plant population for corn is 14,000 to 16,000 per acre. Three cuttings of alfalfa hay are made. Permanent pasture consists mainly of native grasses.

The requirements of improved management vary according to the needs of the soils. The essential requirements include erosion control measures; proper choice and rotation of crops; application of commercial fertilizer, lime, and manure in the proper amounts; proper tillage methods; crop residue management; adequate control of weeds and insects; adequate control of water; maintenance or improvement of tilth and productivity; and conservation of soil material, plant nutrients, and soil moisture. The plant population for corn is 18,000 to 20,000 per acre. Three cuttings are made of alfalfa hay. Permanent pasture consists mainly of suitable grasses and legumes, and it is renovated periodically.

Wildlife Resources [1]

The principal wildlife species of Carver County are ring-necked pheasant, cottontail rabbit, white-tailed deer, gray squirrel, fox squirrel, ruffed grouse, wild duck, muskrat, and mink. There are also many varieties of songbirds and nongame mammals and the usual variety of fish found in the warm-water lakes of the State, including northern pike, walleyed pike, largemouth bass, bluegill, crappie, sunfish, bullhead, and carp.

This county is a poor to fair range for ring-necked pheasant. When pheasants are fairly abundant, the density per square mile in spring is 6 to 10 hens, and in fall, in most parts of the county, 9 to 14 cocks. The best pheasant range is in the southwestern part of the county, on the nearly level to gently rolling uplands of associations 1 and 2. (The associations are shown on the general soil map and are described in the section "General Soil Map.") A range

[1] HANS ULIG, biologist, SCS, helped to prepare this section.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*

[Figures in columns A indicate yields under average management; figures in columns B indicate yields under improved management. Absence of figure indicates the crop is not suited to or is not commonly grown on the soil specified. If estimates are not given for both soils in a mapping unit, yields can be expected to be the same]

Soil	Corn for grain		Corn for silage		Soybeans		Oats		Rotation hay [1]		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Cow-acre-days* [2]
Alluvial land [3]	45	60	9	11	18	22	40	45	2.0	2.5	80	100	70	90
Alluvial land, frequently flooded													60	80
Biscay loam:														
Inadequately drained	50		10		15		25		1.5				80	90
Adequately drained	65	80	13	15	25	32	40	50	2.5	3.5	100	140		
Biscay loam, sandy subsoil variant:														
Inadequately drained	50		10		15		25		1.5				80	90
Adequately drained	65	80	13	15	25	32	40	50	2.5	3.5	100	140		
Burnsville-Hayden complex, 2 to 6 percent slopes:														
Burnsville part	30	40	6	8	7	9	25	35	1.5	2.0	60	80	30	40
Hayden part	55	65	11	13	20	25	45	55	3.0	3.5	120	140	50	90
Burnsville-Hayden complex, 6 to 12 percent slopes:														
Burnsville part	20	30	4	6			25	30	1.2	1.5	50	60	25	30
Hayden part	40	50	8	10	14	18	30	40	2.0	2.5	80	100	50	80
Burnsville-Hayden sandy loams, 12 to 18 percent slopes:														
Burnsville part													25	30
Hayden part													45	65
Burnsville-Hayden sandy loams, 18 to 25 percent slopes:														
Burnsville part													20	25
Hayden part													40	60
Canisteo silty clay loam:														
Inadequately drained	45		9		20		40		1.5				85	100
Adequately drained	65	80	12	15	30	35	50	65	3.0	4.0	120	160		
Canisteo silty clay loam, depressional:														
Inadequately drained													40	80
Adequately drained	55	70	11	13	25	30	45	55	2.0	2.8	80	110		
Chaska silty clay loam: [3]														
Inadequately drained	40		7		18		35		1.2				80	90
Adequately drained	60	70	11	13	25	30	45	60	2.8	3.2	110	125		
Comfrey silty clay loam: [3]														
Inadequately drained	45		8		18		40		1.2				80	90
Adequately drained	70	85	12	15	25	30	50	60	2.8	3.2	110	125		
Comfrey silty clay loam, frequently flooded													40	80
Cordova silty clay loam:														
Inadequately drained	50		10		18		45		1.7				80	100
Adequately drained	70	85	14	16	30	35	55	65	2.5	4.0	100	160		
Cordova and Webster silty clay loams:														
Inadequately drained	50		10		18		45		1.7				80	100
Adequately drained	75	90	15	17	30	35	55	65	3.0	4.0	120	160		
Dakota and Rasset sandy loams, 0 to 2 percent slopes	45	55	9	11	18	22	40	50	2.0	2.5	80	100	50	60
Dakota and Rasset sandy loams, 2 to 6 percent slopes	40	50	8	10	16	20	35	45	1.8	2.2	75	90	50	60
Estherville sandy loam, 0 to 2 percent slopes	40	50	8	10	12	15	30	40	1.5	2.0	60	80	30	40
Estherville sandy loam, 2 to 6 percent slopes	35	50	7	10	10	15	30	35	1.5	2.0	60	80	30	40
Estherville sandy loam, 2 to 6 percent slopes, eroded	30	45	6	9	8	14	25	30	1.4	1.8	60	70	30	40
Estherville sandy loam, 6 to 12 percent slopes	30	40	6	8			25	30	1.2	1.5	50	60	25	35
Estherville sandy loam, 6 to 12 percent slopes, eroded	30	35	4	6			20	25	1.0	1.3	40	50	20	30
Estherville sandy loam, 12 to 18 percent slopes													20	25
Estherville sandy loam, 18 to 25 percent slopes													20	25
Fairhaven silt loam, deep variant, 0 to 3 percent slopes	70	80	14	16	30	35	55	70	3.2	3.8	130	150	85	115
Fairhaven silt loam, sand substratum, 0 to 2 percent slopes	55	65	11	13	25	30	50	60	2.8	3.2	110	130	60	75

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn for grain		Corn for silage		Soybeans		Oats		Rotation hay [1]		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Cow-acre-days* [2]	*Cow-acre-days* [2]
Fairhaven silt loam, sand substratum, 2 to 6 percent slopes	50	60	10	12	25	28	50	60	2. 5	3. 0	100	120	60	75
Fairhaven silt loam, sand substratum, 6 to 12 percent slopes, eroded	40	50	8	10	14	20	40	50	2. 0	2. 5	80	100	45	55
Glencoe silty clay loam:														
Inadequately drained													40	80
Adequately drained	60	75	12	14	30	35	50	60	2. 0	2. 8	80	110		
Hayden clay loam, 6 to 12 percent slopes, severely eroded	40	55	8	10			25	40	2. 0	2. 5	80	100	50	70
Hayden clay loam, 12 to 18 percent slopes, severely eroded									1. 5	2. 0	60	80	40	60
Hayden clay loam, 18 to 25 percent slopes, severely eroded													35	55
Hayden loam, 2 to 6 percent slopes	70	80	14	16	25	30	50	60	3. 0	4. 0	120	160	70	115
Hayden loam, 2 to 6 percent slopes, eroded	60	75	12	14	20	28	45	55	3. 0	3. 8	120	150	75	115
Hayden loam, 6 to 12 percent slopes	60	70	12	14	20	25	45	55	3. 0	3. 5	120	140	70	100
Hayden loam, 6 to 12 percent slopes, eroded	55	65	11	13	18	22	40	50	2. 5	3. 0	100	120	65	95
Hayden loam, 12 to 18 percent slopes	45	55	9	10			35	50	2. 2	2. 7	90	110	50	80
Hayden loam, 12 to 18 percent slopes, eroded	40	50	8	9			30	45	2. 0	2. 5	80	100	50	70
Hayden loam, 18 to 25 percent slopes, eroded													40	60
Hayden loam, 25 to 40 percent slopes													30	55
Hubbard loamy sand, 0 to 2 percent slopes	30	40	6	8	8	10	25	35	1. 0	1. 5	40	60	20	25
Hubbard loamy sand, 2 to 6 percent slopes	30	35	6	7	8	10	25	35	1. 0	1. 5	40	60	20	25
Hubbard loamy sand, 6 to 12 percent slopes	20	25	4	5			20	25	. 4	. 8	20	35	15	20
Hubbard loamy sand, 12 to 18 percent slopes													15	20
Hubbard loamy sand, 18 to 35 percent slopes													15	20
Hubbard sandy loam, 0 to 2 percent slopes	35	45	7	9	12	14	35	40	1. 5	1. 8	60	70	35	45
Hubbard sandy loam, 2 to 6 percent slopes, eroded	35	40	7	8	10	12	30	35	1. 5	1. 8	60	70	30	40
Hubbard sandy loam, 6 to 12 percent slopes, eroded	25	30	5	6	6	8	20	30	1. 2	1. 5	50	60	25	30
Hubbard sandy loam, 12 to 18 percent slopes													25	30
Kasota loam, 0 to 2 percent slopes	65	75	13	15	30	35	55	65	3. 0	3. 5	120	140	70	110
Kasota loam, 2 to 6 percent slopes, eroded	60	70	12	14	28	32	50	60	2. 8	3. 2	110	130	65	85
Kasota sandy loam, 0 to 2 percent slopes	50	60	10	12	20	24	45	55	2. 0	2. 5	80	100	50	65
Kasota sandy loam, 2 to 6 percent slopes, eroded	45	55	9	11	18	22	40	50	2. 0	2. 5	80	100	50	65
Lester loam, 2 to 6 percent slopes	70	85	13	16	30	35	55	70	3. 5	4. 0	140	160	75	115
Lester loam, 2 to 6 percent slopes, eroded	65	75	12	15	28	32	50	65	3. 2	4. 0	130	160	75	115
Lester loam, 6 to 12 percent slopes	60	75	12	14	25	30	50	60	3. 0	3. 5	120	140	60	105
Lester loam, 6 to 12 percent slopes, eroded	55	70	11	13	20	25	45	55	2. 8	3. 2	110	130	60	100
Lester loam, 12 to 18 percent slopes, eroded	50	60	10	12			45	55	2. 2	2. 8	90	120	55	85
Lester-Estherville complex, 2 to 6 percent slopes:														
Lester part	70	80	13	15	30	35	55	65	3. 5	4. 0	140	160	75	115
Estherville part	35	45	7	9	10	12	30	40	1. 8	2. 0	70	80	40	50
Lester-Estherville complex, 6 to 12 percent slopes, eroded:														
Lester part	55	70	11	13			45	55	2. 8	3. 2	110	130	65	100
Estherville part	20	30	4	6			20	25	1. 0	1. 3	40	50	25	30
LeSueur clay loam, 0 to 2 percent slopes	80	90	15	17	32	37	55	70	3. 5	4. 0	140	160	80	120
LeSueur clay loam, 2 to 6 percent slopes	80	90	15	17	32	37	55	70	3. 5	4. 0	140	160	80	120
Marsh														
Mayer loam:														
Inadequately drained	50		10		15		25		1. 5				80	90
Adequately drained	65	80	13	15	25	32	40	50	2. 5	3. 5	100	140		
Oshawa silty clay loam													40	80
Peat and muck, calcareous:														
Inadequately drained													30	80
Adequately drained	45	65	11	15	18	22	30	40	2. 0	2. 5	80	100		
Peat and muck, deep:														
Inadequately drained													30	80
Adequately drained	50	70	11	16	22	28	35	40	2. 0	2. 5	80	100		
Peat and muck, moderately shallow, over loam:														
Inadequately drained													30	80
Adequately drained	55	75	12	17	20	25	35	45	2. 0	2. 5	80	100		

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn for grain		Corn for silage		Soybeans		Oats		Rotation hay [1]		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Cow-acre-days* [2]	*Cow acre days* [2]	*Cow-acre-days* [2]	*Cow-acre-days* [2]
Peat and muck, moderately shallow, over sand													30	80
Rasset loamy sand, 0 to 6 percent slopes	35	45	7	9	10	12	30	40	1. 4	1. 8	55	70	35	40
Rasset loamy sand, 6 to 12 percent slopes	25	35	6	7			25	30	1. 0	1. 5	40	60	25	35
Rasset loamy sand, 12 to 18 percent slopes													25	30
Salida loamy sand, 18 to 40 percent slopes													10	20
Sandy colluvial land	25	35	5	7	8	10	25	35	1. 0	1. 5	40	60	25	35
Sandy lake beaches														
Storden-Lester loams, 6 to 12 percent slopes, eroded:														
Storden part	40	50	8	10	16	20	40	45	2. 5	3. 0	100	120	65	100
Lester part	55	70	11	13	20	25	45	55	2. 8	3. 2	110	130	65	100
Storden-Lester loams, 12 to 18 percent slopes, eroded:														
Storden part	35	45	7	9			30	35	2. 0	2. 5	80	100	45	65
Lester part	45	55	9	11			40	50	2. 0	2. 5	80	100	45	65
Talcot silty clay loam:														
Inadequately drained													40	80
Adequately drained	55	70	11	14	25	30	40	55	2. 0	2. 5	80	100		
Terril loam, 0 to 6 percent slopes	75	90	15	17	32	37	55	70	3. 5	4. 0	140	160	90	120
Terril loam, 7 to 11 percent slopes	65	80	13	15	25	30	50	65	3. 0	3. 5	120	140	70	110
Terril loam, occasionally flooded [3]	55	65	11	13	28	32	50	60	3. 0	3. 5	120	140	80	90
Wadena loam, 0 to 2 percent slopes	55	65	11	13	25	30	50	60	2. 0	2. 5	80	100	55	70
Wadena loam, 2 to 6 percent slopes	50	60	10	12	20	25	45	55	2. 0	2. 5	80	100	55	70
Wadena loam, 6 to 12 percent slopes, eroded	40	50	8	10	16	20	40	50	1. 5	2. 0	60	80	45	55

[1] Estimates are for alfalfa-brome mixtures. Yields of mixtures of timothy and either red clover or alsike clover are 10 to 25 percent less.

[2] Cow-acre-days is a term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture can be grazed during a single grazing season without injury to the sod. An acre of pasture that provides 30 days of grazing for 2 cows has a carrying capacity of 60 cow-acre-days.

[3] Much lower yields must be expected if areas are flooded about once in 5 or 6 years.

better than average is in the northeastern part of the county in association 4, where pheasants are attracted by the numerous marshes and bogs.

White-tailed deer are common throughout most of the county and have increased in numbers in recent years. Deer are most numerous in association 8, within 1 or 2 miles of the Minnesota River; on the very steep hills, bluffs, and ravines of association 7; and just north and east of Lake Waconia, on the irregular, strong slopes and hills of association 4.

Small numbers of ruffed grouse are found in the more extensive wooded areas in the county.

Fox squirrel, gray squirrel, and red squirrel are abundant. They are most numerous in farm shelterbelts and mature woodlands, where they find a good supply of food and an adequate number of den trees.

The best waterfowl habitat in the county is in association 3. The many lakes, marshes, and peat bogs provide nesting places and attract migrating birds. Patterson, Berliner, Goose, Swede, Tiger, and Rice Lakes provide good hunting, and Patterson and Berliner Lakes are well known for production of waterfowl. Association 4, in the northeastern part of the county, also is dotted with lakes, marshes, and bogs, but it is too steep and too heavily wooded to be attractive to waterfowl.

Mink and muskrat are found throughout the county but are most plentiful in the marshy depressions in association 6, near East Union. In fact, these areas appear to be overpopulated. Harvests of mink and muskrat fluctuate annually. The range is from one per square mile to one per 4 square miles. The harvests are influenced by fur prices and therefore do not always indicate the population density.

Most of the lakes that provide good fishing are in association 4. The principal sport fish are northern pike and pan fish.

Rotating crops, planting crops in strips, and seeding ditchbanks and field borders are ways to provide a diversity of cover that attracts and benefits wildlife. Improving farmstead windbreaks, seeding odd areas to grass to provide nesting cover, and protecting areas from overgrazing and wildfire are additional practices that improve the wildlife habitat.

Use of Soils for Woodland [2]

Dense hardwood forest covered nearly all of Carver County at the time of settlement and, in fact, extended over a large part of central Minnesota. The only open

[2] THOR BERGH, woodland conservationist, SCS, and TED NISKANEN, district forester, State of Minnesota Forest Service, helped to prepare this section.

areas were marshes and parts of the terraces and flood plains in the Minnesota River valley. Figure 22 shows the distribution of the original vegetation in the county.

According to a survey made in 1953, about 18 percent of the county was wooded. The northern upland hardwood type covered about 14,600 acres. This type is made up of hard maple, basswood, red oak, white oak, and red elm. The bottom-land hardwood type covered about 8,100 acres. This type is made up of cottonwood, ash, soft maple, and hackberry.

Wood production has been poor in this county. Adequate growing stock has not been maintained; the better quality trees have been cut, and the desirable species have been overcut. The woodland is not protected against fire, and about 90 percent of it is grazed. Poor forestry practices have resulted in poor-quality trees, poor-quality logs, and open, parklike woods.

There were 10 operating sawmills in the county in 1962. The major products were lumber and fenceposts for home use. Miscellaneous products included bowling pins, veneer stock, berry stakes and boxes, pool cues, water skis, and barrel stock. Production of maple syrup is increasing and could be more than doubled if woodland management were improved.

Woodland Groups

More effective management of woodland can be planned if the soils are grouped according to those characteristics that affect the growth of trees and the management of the stand. The soils of Carver County have been placed in nine woodland groups. Each group is made up of soils that are suited to the same kinds of trees, that require about the same management, and that have about the same potential productivity.

The factors considered in placing each soil in a woodland group include potential productivity, which is expressed as site index; species preferred for planting; and soil-related hazards and limitations to be considered in management. These factors are explained in the paragraphs that follow. The ratings are based largely on the experience and judgment of local soil scientists, woodland conservationists, and foresters. They represent the best information now available about the way soil influences the growth and management of trees. The ratings are tentative and are subject to revision as more information becomes available.

Productivity ratings are expressed as *excellent*, *good*, *fair*, and *poor*. These ratings are based on the site index. Site index is the average height, in feet, that the dominant trees of a given species, growing on a specified soil, will reach at 50 years of age. For black ash, green ash, and hard maple, a rating of *poor* indicates a site index of 30 feet; *fair* indicates a site index of 40 feet; *good* indicates a site index of 50 feet; and *excellent* indicates a site index of 60 feet or more. For aspen, basswood, birch, black walnut, elm, oak, jack pine, red pine, and spruce, a rating of *poor* indicates a site index of 40 feet; *fair* indicates a site index of 50 feet; *good* indicates a site index of 60 feet; and *excellent* indicates a site index of 70 feet or more. For cottonwood, soft maple, and white pine, a rating of *poor* indicates a site index of 50 feet; *fair* indicates a site index of 60 feet; *good* indicates a site index of 70 feet; and *excellent* indicates a site index of 80 feet or more.

Seedling mortality refers to the expected loss of naturally occurring or planted seedlings, as a result of unfavorable soil characteristics. Mortality is *slight* if the expected loss is less than 25 percent. It is *moderate* if the expected loss is between 25 and 50 percent. Mortality is *severe* if the expected loss is more than 50 percent.

Plant competition refers to invasion by or growth of undesirable species when openings are made in the canopy. Competition is *slight* if invaders do not prevent adequate regeneration and early growth and do not interfere with the development of planted seedlings. It is *moderate* if the invaders delay but do not prevent the establishment of a normal, fully stocked stand. Competition is *severe* if invaders prevent adequate regeneration or if intensive site preparation and maintenance are needed.

The equipment limitation is *slight* if there are no restrictions on the type of equipment or on the time of year that the equipment can be used. The limitation is *moderate* if the use of equipment is restricted by seasonal wetness that lasts no more than 3 months or if the use of equipment damages tree roots to some extent. The limitation is *severe* if the use of equipment is restricted by wetness that lasts more than 3 months or if the use of equipment causes severe damage to tree roots.

The erosion hazard is the degree of potential loss of soil by wind or water. The hazard is *slight* if erosion is no problem. It is *moderate* if measures are needed to prevent unnecessary loss of soil. It is *severe* if special equipment and special methods of operation are needed to minimize loss and deterioration of the soil.

Each of the nine woodland groups in Carver County is described on the pages that follow. The names of soil series represented are mentioned in the description of each group, but this does not mean that all the soils of a given series are in the unit. To find the woodland classification for any given soil, refer to the "Guide to Mapping Units."

Woodland group 1

This group consists of soils of the Fairhaven, Hayden, Kasota, Lester, LeSueur, Terril, and Wadena series and soils of the Lester-Estherville complex. These soils are moderately deep to deep, medium textured to moderately fine textured, and well drained to moderately well drained. The natural supply of plant nutrients is moderate to high. The organic-matter content is moderately low to high. The moisture-storage capacity is moderate to high, and permeability is moderately rapid to moderately slow. The slope range is 0 to 6 percent.

These are among the most productive soils for crops in the county. Most of the acreage is cleared, but there are wooded pastures and undeveloped woodlots on some of the Hayden, Lester, and LeSueur soils.

These soils grow good-quality timber. They are excellent for basswood, elm, white oak, red oak, and green ash and are good for hard maple, black walnut, red pine, white pine, and white spruce. Basswood, black walnut, red pine, white pine, and white spruce are the most easily established.

Seedling mortality generally is slight. The expected loss of planted stock is less than 25 percent, and adequate regeneration in a natural stand can be expected. If the site has deteriorated because of fire or overgrazing, disking or other seedbed preparation may be needed. In places underplanting is needed to reinforce the stand.

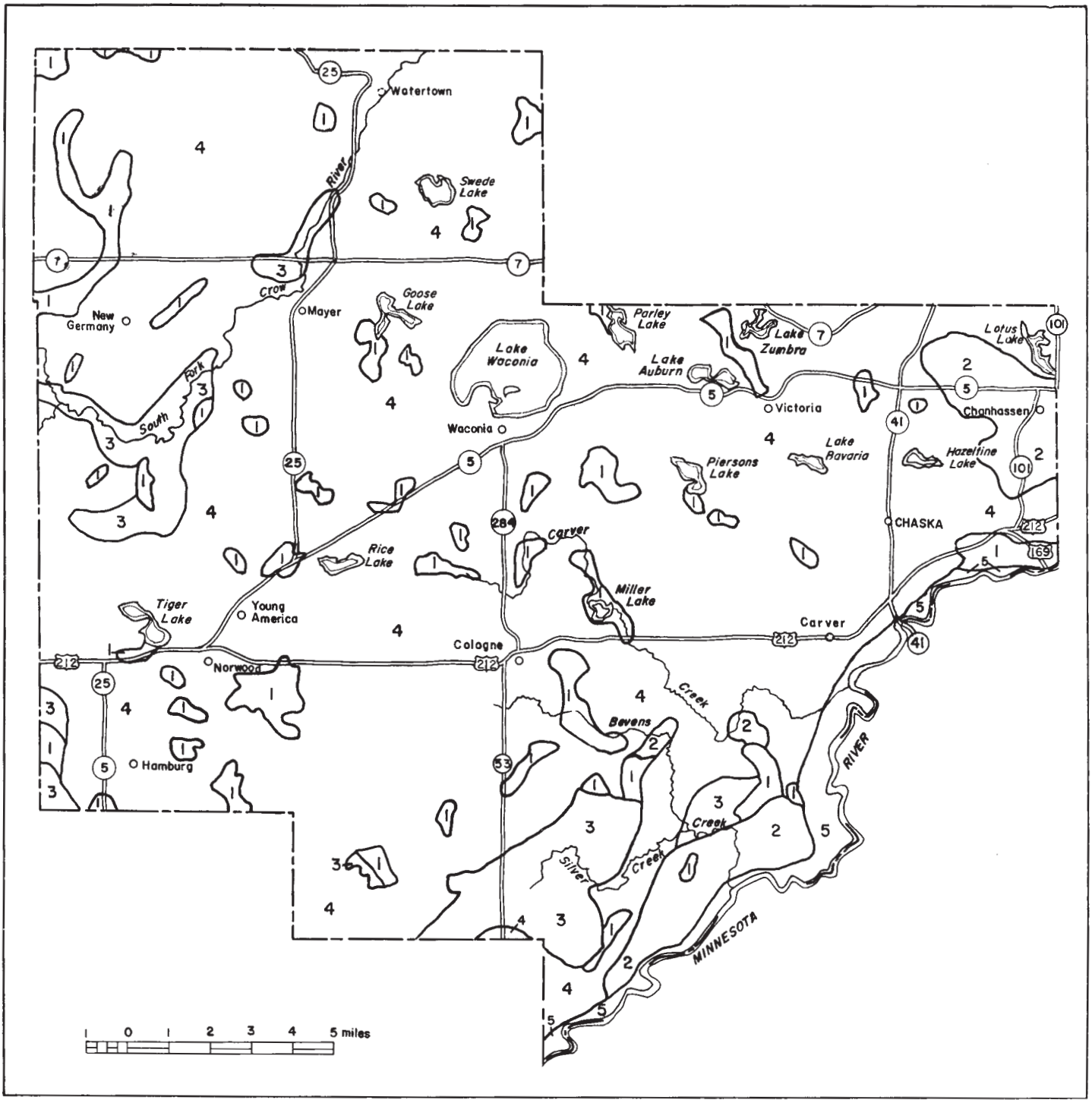

Figure 22.—Original vegetation of Carver County. Number 1 identifies wet prairies, marshes, sloughs, and other grassland where the vegetation consisted of marsh grass, flags, reeds, wild rice, and some willow and alder. Number 2 identifies oak openings and barrens where the vegetation consisted of scrubby groves, some brush and thickets, and scattered trees, mainly bur oak. Number 3 identifies brushland that consisted of generally dense stands of aspen and scattered oak, elm, ash, and basswood. Number 4 identifies hardwood forests of bur oak, white oak, red oak, black oak, elm, basswood, ash, maple, hornbeam, aspen, birch, wild cherry, hickory, butternut, and black walnut. Number 5 identifies hardwood forests on river bottoms, where the main species were elm, ash, cottonwood, boxelder, oak, basswood, soft maple, willow, aspen, and hackberry.

Plant competition is severe. Furrowing, scalping, spraying, or other site preparation generally is needed to insure success of a plantation.

The equipment limitation is slight. These soils can be worked at any time during the year except just after a heavy rain and after snowmelt in spring.

The erosion hazard is slight if protective cover is maintained.

Woodland group 2

This group consists of soils of the Fairhaven, Hayden, Lester, Terril, and Wadena series and soils of the Lester-Estherville complex and the Storden-Lester complex. These soils are moderately deep to deep, medium textured to moderately fine textured, and well drained. The natural supply of plant nutrients is moderate to high. The organic-matter content is low to high. Permeability is moderate to moderately rapid. The slope range is 6 to 18 percent.

Wooded pastures and small undeveloped woodlots are typical on the soils of this group, particularly on the Hayden and Lester soils.

North- and east-facing slopes are excellent for basswood, elm, white oak, red oak, and green ash; good for hard maple, black walnut, white pine, and white spruce; and fair for red pine. Basswood, black walnut, white pine, and white spruce are the most easily established. South- and west-facing slopes and flats are good for basswood and green ash; fair for oak, elm, red pine, and white spruce; and poor for hard maple, black walnut, and white pine. Red pine and redcedar should be selected for planting.

Seedling mortality generally is slight. The expected loss of seedlings is less than 25 percent, and adequate regeneration in a natural stand can be expected. Disking or other site-preparation measures may be needed to insure a satisfactory stand.

Plant competition is severe. Furrowing, scalping, or spraying generally is needed to insure success of a plantation.

The equipment limitation is slight. These soils can be worked at any time during the year except just after a heavy rain and after snowmelt in spring.

The erosion hazard is moderate. Protective cover is needed.

Woodland group 3

This group consists of soils of the Hayden series. These soils are deep, medium textured to moderately fine textured, and well drained. Permeability is moderate to moderately rapid, and the moisture-storage capacity is moderately high. Natural fertility is moderate to high. The organic-matter content is medium to low. The slope range is 18 to 40 percent. Runoff is very rapid.

North- and east-facing slopes are excellent for basswood, elm, white oak, red oak, and green ash; good for hard maple, black walnut, white pine, and white spruce; and poor for red pine. Black walnut, basswood, white pine, and white spruce are easily established. South- and west-facing slopes and flats are good for basswood; fair for green ash and red pine; and poor for oak, hard maple, elm, black walnut, white pine, and white spruce. Red pine and redcedar are easily established.

Seedling mortality is slight to moderate. On the lesser slopes, seedbed preparation that exposes the mineral soil may be beneficial.

Plant competition is moderate to severe. Furrowing, scalping, spraying, and other site-preparation measures are generally needed to insure success of a plantation.

The equipment limitation is moderate to severe. Safety precautions are needed to prevent tipping of equipment. Hand planting is advisable because the slope generally is too steep for tree-planting machines. These soils can be worked at any time of the year except just after a heavy rain and after snowmelt in spring.

The erosion hazard is severe. Permanent cover is essential.

Woodland group 4

This group consists of Dakota and Rasset sandy loams, soils of the Burnsville-Hayden complexes, and soils of the Estherville, Hubbard, and Kasota series. These soils are droughty, are moderately coarse textured to medium textured, and have a sandy and gravelly substratum within a depth of 24 inches. The moisture-storage capacity is low. Permeability is moderately rapid. The organic-matter content is low to high. Natural fertility is moderately low to moderately high. The slope range is 0 to 12 percent.

Except for the Burnsville-Hayden complexes, few areas of these soils are wooded.

North- and east-facing slopes are good for basswood and green ash and fair for oak, elm, red pine, white pine, and white spruce. White pine, white spruce, red pine, and redcedar are the most easily established. South- and west-facing slopes and flats are fair for basswood, green ash, red pine, and white spruce and poor for oak, elm, and white pine. Red pine and redcedar should be selected for planting.

Seedling mortality is slight to moderate. The expected loss of planted stock is less than 25 percent, and adequate regeneration in a natural stand can be expected. It would be advisable to convert hardwood stands to pine.

Plant competition is slight to moderate. Girdling, clearing, spraying, furrowing, scalping, or other site-preparation measures are needed to eliminate brush.

The equipment limitation is slight. These soils can be worked at any time during the year except just after a heavy rain or after snowmelt in spring.

Erosion is a hazard. Protective cover is needed.

Woodland group 5

This group consists of Burnsville-Hayden sandy loams and soils of the Estherville, and Hubbard series. These soils are droughty, are moderately coarse textured to medium textured, and have a sandy and gravelly substratum within a depth of 24 inches. The moisture-storage capacity is low, and permeability is moderately rapid. The organic-matter content generally is low. The natural supply of plant nutrients is low. The slope range is 12 to 25 percent.

These soils support hard maple, basswood, elm, and ash. They are not well suited to hardwoods because of droughtiness and low fertility. Converting hardwood stands to conifers and then planning management to keep the stands from reverting to hardwoods should be considered.

North- and east-facing slopes are fair for basswood, oak, elm, green ash, red pine, white pine, and white spruce. White pine and white spruce should be selected for planting. South- and west-facing slopes and flats are poor for basswood, oak, elm, green ash, red pine, white pine, and

white spruce. Red pine and redcedar are the most easily established.

Seedling mortality is slight to moderate. The loss of planted stock generally is less than 25 percent, but during dry periods it is between 25 and 50 percent and replanting is needed.

Plant competition is slight. Girdling or spraying is needed to control hardwoods and brush. Furrowing, scalping, or other site-preparation measures to expose mineral soil are needed if conifers are to be planted.

The equipment limitation is moderate to severe. Precautions are needed to prevent tipping of equipment on the steeper slopes. Some of the slopes are too steep for tree-planting machines. These soils can be worked at any time during the year except just after a heavy rain and immediately after snowmelt in spring.

The erosion hazard is moderate to severe. A protective cover of vegetation is needed.

Woodland group 6

This group consists of Sandy colluvial land, Sandy lake beaches, and soils of the Hubbard and Rasset series. All of these soils are deep, droughty loamy sands. The moisture-storage capacity is very low, and permeability is rapid. The organic-matter content generally is low. Natural fertility is low. The slope range is 0 to 12 percent.

These soils are not suited to hardwoods. Only a few areas are wooded. Converting hardwood stands to conifers would be advisable.

These soils are good for red pine, jack pine, and white spruce; fair for white pine; and poor for oak and aspen. Red pine, white spruce, white pine, and redcedar are the most easily established.

Seedling mortality is slight to severe, depending on the moisture supply and onsite preparation. If the moisture supply is adequate after planting, the expected loss of pine seedlings is less than 25 percent. If the moisture supply is inadequate, the loss is more than 50 percent. Such measures as scalping and furrowing help to conserve water.

Plant competition is slight. Grasses and weeds make only a sparse cover except during periods of heavy rainfall. Girdling, clearing, and spraying generally are needed to convert oak stands to pine.

Because of the sandy texture of these soils, the limitation is severe for some types of equipment, even light equipment. The soils can be worked during most of the year. Logging operations in summer are likely to damage tree roots.

The hazard of wind erosion is severe. Protective cover is needed. Mulching with straw or hay and light disking before planting help to protect seedlings. Field windbreaks are needed on some areas. One row of either jack pine or red pine, or two or three rows of either or both are the types commonly used. Redcedar can be used as one row of a two-row windbreak, or as one of the exposed rows in a three-row windbreak, but it must be planted on the sunny side.

Woodland group 7

This group consists of soils of the Hubbard, Rasset, and Salida series. All are droughty loamy sands. The moisture-storage capacity is very low, and permeability is rapid. The organic-matter content generally is low to very low. Natural fertility is low to very low. The slope range is 12 to 40 percent.

These soils are too droughty and too low in fertility to be suited to hardwoods. Converting oak stands to pine or redcedar should be considered.

These soils are fair for red pine and jack pine and poor for white pine. North- and east-facing slopes can be planted to red pine and white spruce, and south- and west-facing slopes and flats to red pine and redcedar.

Seedling mortality is slight to severe, depending on the moisture supply and onsite preparation. The loss of planted stock is less than 25 percent if the moisture supply is adequate, but is more than 50 percent if there are prolonged dry periods after the seedlings are planted. Furrowing or scalping generally is needed to insure the survival of seedlings.

Plant competition from overhead vegetation is slight, but competition for moisture from the sparse growth of weeds and grasses is severe. Girdling, clearing, and spraying are needed to control brush.

The equipment limitation is moderate to severe. Because of the slope, precautions are needed to prevent tipping of equipment. Tree-planting machines cannot be used as slopes are more than 12 percent. The use of equipment is limited in summer because of the loose consistency and sandy texture of the soils.

The erosion hazard is severe. A well-maintained, permanent cover of vegetation is essential. Mulching with straw or hay protects both soil and seedlings.

Woodland group 8

This group consists of Alluvial land and soils of the Biscay, Canisteo, Chaska, Comfrey, Cordova, Mayer, and Webster series. These soils are poorly drained, are moderately deep to deep, and have a medium-textured to moderately fine textured surface soil. The moisture-storage capacity is high, and permeability is moderate to moderately slow. The organic-matter content is high. Natural fertility is high. The water table is seasonally fairly high. The slope range is 1 to 3 percent.

If adequately drained, these soils are highly productive of crops. Most of the acreage is cleared, but there are wooded pastures and undeveloped woodlots on some of the Cordova soils.

These soils grow good to excellent timber. They are excellent for cottonwood and aspen and good for elm, basswood, oak, soft maple, and black ash. Basswood, soft maple, and cottonwood grow the best and are the most easily established.

Seedling mortality is slight. The loss of planted stock can be expected to be less than 25 percent, and adequate regeneration in a natural stand can be expected. Disking or other seedbed preparation may be needed.

Woodland group 9

This group consists of deep silty soils in small depressions and extensive areas of peat bogs, marsh, and old river channels. It includes soils of the Canisteo, Comfrey, Glencoe, Oshawa, and Talcot series, Peat and muck, Marsh, and Alluvial land, frequently flooded. The seasonal water table is very high. Undrained areas or areas that are not protected from flooding are covered with water for long periods and are too wet to be suitable for wood crops. Drained areas are too well suited to field crops to be used for timber production.

Soils in Engineering

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, particle size, plasticity, and reaction. Depth to the water table, depth to bedrock, and topography also are important.

The information in this publication can be used to—

1. Make studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the soil properties that affect the planning of agricultural drainage systems, farm ponds, irrigation systems, and terraces or diversions.
3. Make preliminary evaluations that will aid in selecting locations for highways, airports, pipelines, and cables, and in planning detailed investigations at the selected locations.
4. Locate probable sources of sand and gravel and other construction material.
5. Correlate performance with soil mapping units to develop information that will be useful in planning engineering practices and in designing and maintaining engineering structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement other published information, such as maps, reports, and aerial photographs, that is used in preparation of engineering reports for a specific area.
8. Develop other preliminary estimates for construction purposes.

With the soil map for identification of soil areas, the engineering interpretations reported here can be useful for many purposes. *It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the depths of layers here reported.*

Some of the terms used by soil scientists have a special meaning in soil science that may not be familiar to engineers. These terms are defined in the Glossary.

Engineering Classification Systems

Two systems of classifying soils for engineering purposes are in general use: the AASHO system (*1*) [3] and the Unified system (*11*). Both (*6*) are used in this survey.

Most highway engineers classify soil material in accordance with the system approved by the American Association of State Highway Officials (AASHO). In this system all soil material is classified in seven principal groups. The classification is based on mechanical analysis and plasticity index data. The groups range from A–1, which consists of soils that have the highest bearing capacity and are the best for subgrade, to A–7, which consists of soils that have the lowest strength when wet and are the poorest for subgrade. Within each group the relative engineering value of the soil material is indicated by a group index number. The numbers range from 0, for the best material, to 20, for the poorest. The group index number is shown in parentheses following the soil group symbol in the column headed "AASHO" in table 3.

Some engineers prefer to use the Unified classification system. In this system soils are identified according to their texture and plasticity and their performance as engineering construction material. There are eight classes of coarse-grained soils, six classes of fine-grained soils, and one class of highly organic soils.

Table 3 shows the AASHO and the Unified classification of specified soils in the county, as determined by laboratory tests. Table 4 shows the estimated classification of all the soils in the county according to both systems.

Engineering Test Data

Soil samples representing seven soil series in the county were tested in accordance with standard procedures to help evaluate the soils for engineering purposes. Each of the seven soil types was sampled at three different locations. The samples tested represent modal types and extremes within the named series. The tests were made by the Minnesota Department of Highways in cooperation with the U.S. Department of Commerce, Bureau of Public Roads. The results of these tests are given in table 3.

The engineering classifications given in table 3 are based on the data obtained by mechanical analysis and on the liquid limit and plasticity index. The mechanical analysis was made by combined sieve and hydrometer methods.

Liquid limit and plasticity index indicate the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from semisolid to plastic. As the moisture content is further increased, the material changes from plastic to liquid. The *plastic limit* is the moisture content at which the soil material passes from semisolid to plastic. The *liquid limit* is the moisture content at which the material changes from plastic to liquid. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil is plastic.

Table 3 also gives moisture-density, or compaction, data for the soils tested. If soil material is compacted at successively higher moisture content and the compactive effort remains constant, the dry density of the compacted material increases as the moisture content increases until the optimum moisture content is reached. After that, the density decreases as the moisture content increases. The highest dry density obtained is the *maximum dry density*, and the corresponding moisture content is the *optimum moisture*. Moisture density data are important in planning earthwork because, as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density at approximately optimum moisture content.

Engineering Interpretations

Estimates of properties significant in engineering are listed in table 4 (p. 58). The estimates are based on the

[3] Italic numbers in parentheses refer to Literature Cited, p. 86.

data shown in table 3, on information compiled during the survey, and on tests on similar soils in other counties.

Estimates of the suitability of the soils for various engineering uses are given in table 5 (p. 62). Features that are likely to affect the selection, design, and application of various engineering practices were considered, and evaluations were based on test data and field performance.

A soil feature favorable for one kind of engineering use is likely to be unfavorable for another. For example, a rapidly permeable substratum is unfavorable for a farm pond but favorable for an artificial drainage system.

Frost action is a serious limitation in Carver County. Suspending earthwork in winter to avoid using frozen soil material would be advisable but is impractical. Earthwork in winter is possible in gravelly and sandy material that contains only a small amount of silt and clay if the frozen material is removed and the rest is easily compacted.

Susceptibility to frost action was considered in determining the suitability of the soils as a source of sand and gravel. Soils that are a mixture of silt, clay, and coarser textured materials are not so susceptible to frost heave and subsequent frost boils as soils that are high in content of silt or very fine sand. If 10 percent or more of the soil material can pass a number 200 sieve, the soil is susceptible to damaging frost action.

Uniformity of material is most important in grading design. Frost heave occurs if there are differences in expansion between one material and another. Some deposits of glacial till contain lenses or pockets of silt and fine sand and consequently are susceptible to differential frost heave. If a highway subgrade is laid over glacial till, the subgrade material should contain a thick layer of material that is not susceptible to damaging frost heave.

In many of the wet depressions in this county, the material is highly organic and is more than 20 feet deep. This organic material, peat and muck, has low strength and is not suitable for use in foundations of roads or other engineering structures. It should be removed and replaced with suitable material.

In areas that are poorly drained or have a high water table, roadways should be built on embankments so that the surface pavement is at least 4 feet above the level of the water table. Some soils that have a high water table can be made more suitable for borrow and roadway excavation by constructing drainage ditches before the earthwork is started. Underdrains are essential where the soil is unstable because of a perched water table or a normally high water table.

Soils in Community Development

The suburbs of Minneapolis are steadily expanding into areas in the eastern part of the county that were formerly used for farming. As the population increases in these areas, so does the demand for shopping centers, schools, parks, golf courses, and other community developments. The suitability of the soils must be considered in selecting a site for a residence, a highway, or an industrial facility. The best sites generally are the nearly level to gently sloping, deep, well-drained soils that are fairly free of stones and boulders.

The limitations of the soils for use as septic tank filter fields are important because most of the suburban developments in the county are in areas beyond existing sewerage lines. Each site must be examined closely to determine the capacity of the soil to absorb and filter effluent from septic tanks (*10*). Some soils absorb effluent rapidly; others absorb it very slowly. Soils that have a slow rate of absorption require a larger filter field than those that have a rapid rate. Most septic tank failures occur because the soils are poorly drained or are dense, compact, and fine textured. In wet weather and for long periods afterwards, such soils are saturated and do not absorb effluent from septic tanks. Other causes of failure are a slope of more than 12 percent, a seasonal high water table, flooding, shallowness over bedrock, or a cemented substratum. A percolation test, which measures the rate of water moving through the soil, indicates the degree of limitation and also provides the information needed to calculate the size of the filter field.

The interpretations presented in this section can be used as a guide in locating areas where septic tanks can be expected to function satisfactorily, but they do not eliminate the need for detailed investigation at the site.

Building Site Groups

The soils of Carver County have been assigned to 11 building site groups. The soils in each group are similar in those characteristics that affect their suitability for residential and industrial construction. The characteristics considered are internal drainage, risk of flooding, soil depth, percent of slope, texture of the substratum, and stoniness. The soils were examined to a depth of 5 feet. Economic factors, such as nearness to roads and established centers, were not considered.

Descriptions of the 11 building site groups begin below and continue on pages 72, 73, and 74. The limitations of the soils for specified purposes are expressed as *slight*, *moderate*, and *severe*. The limitation is *slight* if it is easy to overcome. The limitation is *moderate* if good management and careful design are needed. It is *severe* if usage of the soil is questionable.

With the use of the soil map for identification, the interpretations reported here can be useful in selecting suitable locations for residences, stores, factories, schools, and similar facilities. It should be emphasized that these interpretations do not eliminate the need for detailed onsite investigation. Also, engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

The names of soil series represented are mentioned in the description of each group, but this does not mean that all the soils of a given series are in the group. To find the classification for any given soil, refer to the "Guide to Mapping Units."

Building site group 1

This group consists of soils of the Dakota, Estherville, Fairhaven, Hubbard, Kasota, Rasset, and Wadena series. These soils are excessively drained to well drained. The slope range is 0 to 6 percent. The texture of the surface soil ranges from loamy sand to silt loam. All of these soils are underlain by sand or gravel, or both, within a depth of 3½ feet. They do not have a seasonal high water table and are not subject to flooding.

TABLE 3.—*Engineering*

[Tests performed by Minnesota Department of Highways in cooperation with U.S. Department of Commerce, Bureau of Public

Soil name and location	Parent material	Minnesota report number (SS62)	Depth	Horizon	Moisture-density data[1]	
					Maximum dry density	Optimum moisture
			In.		*Lb. per cu. ft.*	*Pct.*
Biscay loam:						
NW¼NW¼, sec. 17, T. 116 N., R. 26 W. (Modal.)	Glacial outwash on outwash plain.	1708	0–10	A1	95	23
		1709	19–24	Bg2	119	12
		1710	34–44	C	123	11
NW¼SW¼, sec. 15, T. 116 N., R. 26 W. (Maximal.)	Glacial outwash on outwash plain.	1711	0–8	A1p	93	23
		1712	21–26	Bg3	121	11
		1713	29–42	D2	115	14
SW¼NE¼, sec. 2, T. 116 N., R. 26 W. (Minimal.)	Glacial outwash on outwash plain.	1714	0–10	A1p	101	19
		1715	17–24	Bg2	125	10
		1716	30–48	C2	124	13
Cordova silty clay loam:						
SE¼NE¼, sec. 6, T. 114 N., R. 25 W. (Modal.)	Glacial till on ground moraine of Mankato Age.	1672	0–7	A1	79	31
		1673	13–19	B22g	98	21
		1674	32–44	Cg2	100	20
SW¼SE¼, sec. 36, T. 115 N., R. 25 W. (Maximal.)	Glacial till on ground moraine of Mankato Age.	1678	0–7	A1	81	33
		1679	15–21	B22g	103	20
		1680	25–35	Cg1	103	19
NW¼SW¼, sec. 36, T. 117 N., R. 26 W. (Minimal.)	Glacial till on ground moraine of Mankato Age.	1675	0–8	A1p	83	29
		1676	8–13	B21	96	23
		1677	27–48	Cg3	106	17
Fairhaven silt loam, sand substratum:						
SW¼SW¼, sec. 24, T. 115 N., R. 24 W. (Modal.)	Alluvium on outwash plain.	1690	0–7	Ap	102	18
		1691	20–28	B23	102	21
		1692	42–52	C3	103	16
SE¼SE¼, sec. 36, T. 115 N., R. 24 W. (Maximal.)	Alluvium on outwash plain.	1696	0–6	Ap	108	17
		1697	10–18	B22	109	15
		1698	40–48	C	125	11
NW¼SW¼, sec. 1, T. 114 N., R. 24 W. (Minimal.)	Alluvium on outwash plain.	1693	0–6	Ap	114	13
		1694	15–23	B22	112	14
		1695	25–42	C	110	14
Hayden loam:						
NE¼NW¼, sec. 7, T. 116 N., R. 23 W. (Modal.)	Glacial till on ground moraine of Mankato Age.	1663	5–9	A22	118	11
		1664	12–22	B21	100	22
		1665	38–48	C2	109	17
SW¼NE¼, sec. 6, T. 117 N., R. 25 W. (Maximal.)	Glacial till on ground moraine of Mankato Age.	1666	4–8	A21	106	17
		1667	20–32	B22	101	19
		1668	49–60	C1	109	16
NW¼NW¼, sec. 36, T. 115 N., R. 25 W. (Minimal.)	Glacial till on ground moraine of Mankato Age.	1669	7–10	A22	100	20
		1670	21–28	B23	92	27
		1671	32–48	C	101	21

See footnotes at end of table.

test data

Roads (BPR) in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [2]											Liquid limit	Plasticity index	Classification	
Percentage passing sieve—							Percentage smaller than—						AASHO	Unified [3]
2-in.	¾-in.	⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
				100	81	43	40	31	14	13	39	9	A-4(2)	SM
			100	98	78	32	30	25	16	14	28	11	A-2-6(0)	SC
[4] 100	89	83	76	70	26	5	(5)				[6] NP	NP	A-1-b(0)	SP
			100	98	80	53	50	42	26	20	50	19	A-7-5(9)	ML
	100	99	97	89	55	32	31	24	16	14	36	18	A-2-6(0)	SC
100	99	95	89	79	4	2	(5)				NP	NP	A-1-b(0)	SP
		100	99	96	68	37	31	26	11	9	42	9	A-5(0)	SM
		100	98	89	45	19	(5)				25	6	A-1-b(0)	SM-SC
[7] 100	81	74	64	54	17	4	(5)				NP	NP	A-1-b(0)	SP
				100	96	70	62	47	20	13	52	12	A-7-5(10)	OH
		100	99	97	92	66	58	52	39	35	49	22	A-7-6(12)	ML-CL
		100	98	95	83	57	53	45	35	26	46	20	A-7-6(9)	ML-CL
				100	95	69	58	45	21	13	52	15	A-7-5(11)	OH
		100	99	97	90	64	59	53	37	32	50	24	A-7-6(12)	ML-CL
	100	98	97	95	87	63	54	45	33	26	41	17	A-7-6(8)	ML-CL
			100	99	93	65	59	45	23	17	54	18	A-7-5(11)	OH
			100	99	93	66	59	49	33	26	48	21	A-7-6(12)	ML-CL
	100	98	94	92	84	61	53	43	29	22	37	17	A-6(8)	CL
				100	94	67	58	43	20	14	33	8	A-4(6)	ML-CL
				100	96	79	76	57	26	20	39	14	A-6(10)	ML-CL
				100	91	1	(5)				NP	NP	A-3(0)	SP
		100	99	98	89	54	46	29	14	8	28	6	A-4(4)	ML-CL
				100	96	74	65	36	22	19	30	8	A-4(8)	ML-CL
100	91	84	77	67	32	3	(5)				NP	NP	A-1-b(0)	SP
				100	91	50	35	21	10	8	22	0	A-4(3)	SM
				100	95	67	49	30	15	12	26	3	A-4(6)	ML
	99	98	96	93	29	1	(5)				NP	NP	A-1-b(0)	SP
	100	99	97	94	83	46	38	28	15	11	24	4	A-4(2)	SM-SC
	100	99	96	93	83	56	50	40	29	25	45	20	A-7-6(9)	ML-CL
	100	99	96	92	83	54	47	36	23	15	26	8	A-4(4)	CL
		100	99	98	91	62	54	37	15	7	27	5	A-4(5)	ML-CL
		100	99	98	89	59	52	42	31	28	42	16	A-7-6(7)	ML-CL
	100	99	97	93	83	53	49	36	21	16	33	13	A-6(5)	CL
			100	99	95	76	68	53	24	15	36	11	A-6(8)	ML-CL
		100	98	97	91	68	65	56	41	33	56	28	A-7-6(16)	MH-CH
		100	98	95	88	68	62	52	34	23	42	17	A-7-6(10)	ML-CL

TABLE 3.—*Engineering*

Soil name and location	Parent material	Minnesota report number (SS62)	Depth	Horizon	Moisture-density data[1]	
					Maximum dry density	Optimum moisture
			In.		*Lb. per cu. ft.*	*Pct.*
Kasota loam:						
NE¼NW¼, sec. 2, T. 114 N., R. 24 W. (Modal.)	Stratified sand on outwash plain.	1652	0–7	A1p	108	15
		1653	11–20	B22	93	25
		1654	40–48	C	104	16
NE¼NE¼, sec. 11, T. 114 N., R. 24 W. (Maximal.)	Stratified gravel and sand on outwash plain.	1655	0–8	A1p	97	20
		1656	16–25	B22	102	19
		1657	28–36	B24	85	29
		1658	39–48	C2	121	10
SW¼SW¼, sec. 35, T. 115 N., R. 24 W. (Minimal.)	Stratified sand on outwash plain.	1659	0–9	A1p	106	16
		1660	16–20	B22	99	21
		1661	35–45	C	107	14
		1662	55–60	C1	116	14
Lester loam:						
SW¼NW¼, sec. 7, T. 115 N., R. 25 W. (Modal.)	Glacial till on ground moraine of Mankato Age.	1684	0–6	A1	95	23
		1685	19–28	B22	107	17
		1686	40–48	C	109	17
NE¼NE¼, sec. 36, T. 115 N., R. 26 W. (Maximal.)	Glacial till on ground moraine of Mankato Age.	1687	0–6	A1	76	36
		1688	22–26	B23	93	24
		1689	45–55	C	108	18
NW¼SE¼, sec. 33, T. 116 N., R. 25 W. (Minimal.)	Glacial till on ground moraine of Mankato Age.	1681	0–7	A1	88	26
		1682	13–18	B22	108	15
		1683	41–48	C3	110	15
LeSueur clay loam:						
SE¼NW¼, sec. 13, T. 115 N., R. 26 W. (Modal.)	Glacial till on ground moraine of Mankato Age.	1702	0–8	A1	83	30
		1703	15–23	B22	99	21
		1704	35–45	C2	106	17
NE¼NW¼, sec. 5, T. 114 N., R. 24 W. (Maximal.)	Glacial till on ground moraine of Mankato Age.	1705	0–7	A1	78	33
		1706	18–28	B22	88	28
		1707	39–46	C2	100	22
NW¼NW¼, sec. 11, T. 116 N., R. 26 W. (Minimal.)	Glacial till on ground moraine of Mankato Age.	1699	0–7	A1	82	30
		1700	21–26	B22	105	18
		1701	33–48	C2	106	18

[1] Based on AASHO Designation: T 99–57, Method C (*1*).

[2] Mechanical analysis according to AASHO Designation: T 88–57 (*1*). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

test data—Continued

Mechanical analysis [2]											Liquid limit	Plasticity index	Classification	
Percentage passing sieve—							Percentage smaller than—						AASHO	Unified [3]
2-in.	¾-in.	⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
				100	97	59	53	35	16	10	28	6	A–4(5)	ML–CL
				100	99	84	78	71	58	50	58	26	A–7–5(18)	MH–CH
				100	77	2	[5]				NP	NP	A–3(0)	SP
				100	98	79	66	46	21	10	36	9	A–4(8)	ML or CL
				100	99	73	65	53	36	31	41	16	A–7–6(10)	ML–CL
				100	99	86	82	80	71	62	82	48	A–7–5(20)	CH
100	97	91	81	63	11	2	[5]				NP	NP	A–1–b(0)	SP
				100	97	53	44	30	15	10	27	5	A–4(4)	ML–CL
				100	98	73	68	60	48	41	52	23	A–7–5(15)	MH–CH
		100	99	98	89	6	[5]				NP	NP	A–3(0)	SP
	100	92	78	60	18	3	[5]				NP	NP	A–1–b(0)	SP
		100	99	98	88	52	43	27	11	9	39	11	A–6(3)	OL
			100	98	88	56	50	39	27	21	38	16	A–6(6)	CL
	100	99	97	95	87	59	53	39	25	16	34	12	A–6(6)	ML–CL
			100	99	93	71	66	47	19	13	60	20	A–7–5(14)	OH
		100	99	98	94	78	71	61	44	36	56	25	A–7–5(17)	MH–CH
		100	99	94	85	56	47	37	21	17	36	13	A–6(5)	ML–CL
	100	100	98	97	89	59	57	37	15	9	46	14	A–7–5(8)	ML or OL
	100	98	97	93	82	51	42	36	26	21	40	16	A–6(5)	ML–CL
		100	98	94	86	60	50	35	25	17	33	10	A–4(5)	ML–CL
			100	99	94	70	62	45	19	13	50	16	A–7–5(11)	ML or OL
		100	99	98	92	65	58	49	36	31	46	17	A–7–6(10)	ML
		100	99	95	86	59	50	41	25	18	36	15	A–6(7)	CL
				100	96	84	74	54	25	17	58	13	A–7–5(13)	MH or OH
			100	99	96	82	76	69	52	42	62	26	A–7–5(18)	MH
		100	98	95	86	58	51	38	28	19	43	17	A–7–6(8)	ML–CL
				100	95	71	64	47	18	14	53	17	A–7–5(13)	MH or OH
	100	99	98	96	89	61	54	45	32	28	45	21	A–7–6(10)	CL
	100	99	98	97	90	62	56	44	30	21	36	14	A–6(7)	CL

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within 2 points of the A-line are to be given a borderline classification. (Examples of borderline classifications obtained by this use are SM–SC, ML–CL, and MH–CH.)

[4] An estimated 3 percent of material was larger than 3 inches in diameter and was discarded in field sampling.

[5] Data not available.

[6] Nonplastic.

[7] An estimated 10 percent of material was larger than 3 inches in diameter and was discarded in field sampling.

TABLE 4.—*Estimated*

Soil and map symbol	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
	Ft.	*In.*		
Alluvial land (Al, Au)	(2)	(2)	(2)	(2)
Biscay:				
Loam (Bc)	1–4	0–13	Loam	SM or ML
		13–27	Loam or sandy clay loam	SC or CL
		27–31	Loam to sandy loam	SC
		31–45	Sand and gravel	SP or GP
Loam, sandy subsoil variant (Bd)	1–4	0–13	Loam	SM or ML
		13–37	Sandy clay loam	SC or CL
		37–46	Gravel and sand	SP or GP
		46–54	Sand	SP
Burnsville (BhB, BhC, BuD, BuE)	10+	0–12	Sandy loam	SM
For properties of Hayden soils in mapping units BhB, BhC, BuD, and BuE refer to Hayden soils.		12–16	Coarse sandy loam	SM
		16–40	Gravel and sand	GW
Canisteo:				
Silty clay loam (Ca)	1–4	0–11	Silty clay loam	OH
		11–30	Silty clay loam	CL
		30–50	Silty clay loam or clay loam	CL
Silty clay loam, depressional (Cd)	0–3	0–7	Muck	Pt
		7–24	Silty clay loam	MH
		24–48	Clay loam	CL
Chaska (Ch)	0–4	0–22	Silty clay loam	MH
		22–50	Loam	ML or ML–CL
Comfrey (Cm, Co)	0–4	0–21	Silty clay loam	MH
		21–48	Silty clay loam	CL
Cordova (Cs, Cw)	1–4	0–9	Silty clay loam	OH
For properties of Webster soils in mapping unit Cw, refer to Webster soils.		9–24	Silty clay loam	ML–CL
		24–52	Clay loam	ML–CL or CL
Dakota (DrA, DrB)	10+	0–11	Sandy loam	SM
For properties of Rasset soils in mapping units DrA and DrB, refer to Rasset soils.		11–29	Loam to sandy loam	SM–SC or CL
		29–50	Fine sand	SP
Estherville (EsA, EsB, EsB2, EsC, EsC2, EsD, EsE).	10+	0–10	Sandy loam	SM
		10–21	Loam to sandy loam	ML, SM, or SC
		21–40	Gravel and sand	GW, GP, or SP
Fairhaven:				
Deep variant (FhA)	10+	0–10	Silt loam	ML–CL or OL
		10–47	Silt loam to silty clay loam	ML–CL or ML
		47–60	Very fine sand	SP
Sand substratum (FaA, FaB, FaC2)	10+	0–7	Silt loam	ML–CL or OL
		7–31	Silty clay loam	ML–CL or CL
		31–52	Sand	SP
Glencoe (Ge)	0–3	0–9	Muck	Pt
		9–15	Silty clay loam	OL–CL
		15–44	Clay loam	CL
		44–54	Clay loam	CL
Hayden:				
Loam (HaB, HaB2, HaC, HaC2, HaD, HaD2, HaE2, HaF, HcC3, HcD3, HcE3,).	10+	0–9	Loam	ML–CL or SM
		9–39	Clay loam	ML–CL or CL
		39–52	Loam	CL
Hubbard:				
Loamy sand (HdA, HdB, HdC, HdD, HdF)	10+	0–18	Loamy sand	SM–SP
		18–52	Sand	SP
Sandy loam (HuA, HuB2, HuC2, HuD)	10+	0–20	Sandy loam	SM
		20–31	Loamy sand	SM–SP
		31–48	Sand	SP

See footnotes at end of table.

properties

Classification—Continued	Percentage passing sieve—			Permeability	Available water capacity [1]	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
(2)	(2)	(2)	(2)	*In. per hr.* (2)	*In. per in. of soil* (2)	*pH* (2)	Low to moderate.
A-4	95–100	90–100	45–60	0. 6–2. 0	0. 20	6. 6–7. 8	Low to moderate.
A-4	95–100	90–100	35–55	0. 6–2. 0	. 17	6. 6–7. 8	Low to moderate.
A-2 or A-4	90–100	80–90	25–45	2. 0–6. 3	. 12	6. 6–7. 8	Low to moderate.
A-1	45–90	40–80	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A-4	95–100	90–100	45–60	0. 6–2. 0	. 20	6. 6–7. 8	Low to moderate.
A-4	95–100	90–100	40–55	0. 6–2. 0	. 17	6. 6–7. 8	Low to moderate.
A-1	45–90	40–80	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A-1	95–100	90–100	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A-2	95–100	85–95	25–35	0. 6–2. 0	. 13	5. 6–6. 5	Low.
A-2 or A-1	70–80	85–95	20–30	2. 0–6. 3	. 10	5. 6–6. 5	Low.
A-1	40–50	35–50	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A-7	95–100	95–100	80–90	0. 2–0. 6	. 25	7. 4–7. 8	Moderate to high.
A-7	95–100	95–100	80–90	0. 2–0. 6	. 20	7. 4–7. 8	Moderate to high.
A-6 or A-7	95–100	95–100	60–85	0. 2–0. 6	. 17	7. 4–7. 8	Moderate to high.
A-8				0. 6–2. 0	. 50	7. 4–7. 8	Moderate.
A-7	95–100	95–100	80–90	0. 2–0. 6	. 25	7. 4–7. 8	Moderate to high.
A-7	95–100	95–100	65–80	0. 2–0. 6	. 17	7. 4–7. 8	Moderate to high.
A-7	95–100	95–100	85–95	0. 2–0. 6	. 20	7. 4–7. 8	Moderate to high.
A-4	95–100	95–100	70–80	0. 6–2. 0	. 17	7. 4–7. 8	Moderate.
A-7	95–100	95–100	80–90	0. 2–0. 6	. 25	6. 1–7. 8	Moderate to high.
A-7	95–100	95–100	80–90	0. 2–0. 6	. 17	6. 6–7. 8	Moderate to high.
A-7	95–100	95–100	75–85	0. 2–0. 6	. 20	6. 1–7. 3	Moderate to high.
A-7	95–100	95–100	75–85	0. 2–0. 6	. 18	5. 1–6. 5	High.
A-7 or A-6	95–100	95–100	55–70	0. 6–2. 0	. 17	7. 4–7. 8	Moderate to high.
A-2 or A-4	95–100	95–100	25–50	2. 0–6. 3	. 13	5. 6–6. 5	Low.
A-2 or A-4	95–100	95–100	30–60	2. 0–6. 3	. 20	5. 6–6. 5	Low.
A-3	95–100	95–100	2–5	6. 3+	. 03	5. 6–6. 5	Low.
A-2 or A-4	95–100	70–80	25–50	2. 0–6. 3	. 12	5. 6–6. 5	Low.
A-2 or A-4	90–95	75–85	30–60	2. 0–6. 3	. 10	5. 6–6. 5	Low.
A-1	35–55	25–40	2–5	6. 3+	. 02	7. 4–7. 8	Low.
A-4	95–100	95–100	55–85	2. 0–6. 3	. 20	6. 1–6. 5	Low to moderate.
A-4 or A-6	95–100	95–100	65–85	2. 0–6. 3	. 18	5. 6–6. 5	Moderate.
A-3	75–95	65–95	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A-4	95–100	95–100	55–85	2. 0–6. 3	. 20	6. 1–6. 5	Low to moderate.
A-4 or A-6	95–100	95–100	75–85	2. 0–6. 3	. 18	5. 6–6. 5	Moderate.
A-3	75–95	65–95	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A-8				0. 6–2. 0	. 50	6. 1–7. 3	Moderate.
A-7	95–100	95–100	75–90	0. 2–0. 6	. 25	6. 1–7. 3	Moderate to high.
A-7	90–100	90–100	70–85	0. 2–0. 6	. 20	6. 1–7. 3	Moderate to high.
A-7	90–100	90–100	65–80	0. 6–2. 0	. 17	7. 4–7. 8	Moderate to high.
A-4	95–100	95–100	45–75	0. 6–2. 0	. 18	6. 1–6. 5	Moderate.
A-7	95–100	90–100	55–75	0. 6–2. 0	. 17	5. 1–6. 1	Moderate to high.
A-4 or A-6	95–100	90–100	50–70	0. 6–2. 0	. 17	7. 4–7. 8	Moderate.
A-2	95–100	95–100	10–15	6. 3+	. 06	5. 6–6. 5	Low.
A-3	95–100	95–100	2–5	6. 3+	. 02	5. 6–6. 5	Low.
A-2	95–100	95–100	20–30	2. 0–6. 3	. 13	5. 6–6. 5	Low.
A-2	95–100	95–100	10–15	6. 3+	. 03	5. 6–6. 5	Low.
A-3	95–100	95–100	2–5	6. 3+	. 03	5. 6–6. 5	Low.

TABLE 5.—*Estimated*

Soil and map symbol	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
Kasota:				
Loam (KaA, KaB2)	10+	0–6	Loam	ML–CL or OL
		6–11	Clay loam	CL
		11–28	Clay loam or clay	MH or CH
		28–50	Sand	SP
Sandy loam (KsA, KsB2)	10+	0–11	Sandy loam	SM
		11–24	Clay loam or clay	MH or CH
		24–43	Loamy sand to sand	SM–SP
		43–50	Sand	SP
Lester (LaB, LaB2, LaC, LaC2, LaD2, LeB, LeC2)—For properties of Estherville soils in mapping units LeB and LeC2, refer to Estherville soils.	10+	0–9	Loam	OL–OH
		9–40	Clay loam	CL
		40–48	Clay loam	ML–CL
LeSueur (LsA, LsB)	3–8	0–11	Clay loam	OL or OH
		11–30	Clay loam	ML, CL, or MH
		30–40	Clay loam	CL
Marsh (Ma).[3]				
Mayer (My)	1–4	0–18	Loam	SM or ML
		18–33	Sandy clay loam	SC or CL
		33–48	Sand and gravel	SP or GP
Oshawa (Os)	0–3	0–42	Silty clay loam	ML
Peat and muck (Pc, Pd, Pm, Ps)	0–3	[4] 0–42	Peat and muck	Pt
Rasset (RaB, RaC, RaD)	10+	0–11	Loamy sand	SM
		11–21	Sandy loam	SM
		21–54	Sand with bands of loamy sand and sandy clay loam.	SM–SP with bands of SM and SC
Salida (SaF)	10+	0–10	Loamy sand	SM
		10–42	Sand and gravel	GW, GP, or SP
Sandy colluvial land (Sc)	4–10	0–52	Loamy coarse sand	SM–GM
Sandy lake beaches (Sk)	0–4		(2)	(2)
Storden (SlC2, SlD2)—For properties of Lester soils in mapping units SlC2 and SlD2, refer to Lester soils.	10+	0–6	Loam	ML
		6–48	Clay loam	ML–CL
Talcot (Ta)	0–3	0–23	Silty clay loam	OH
		23–30	Silty clay loam	CL
		30–36	Loamy sand	SM
		36–50	Sand and gravel	SP or GP
Terril:				
Loam (TeB, TeC)	3–8	0–39	Loam	ML or OL
		39–52	Clay loam	CL
Loam, occasionally flooded (To)	2–4	0–27	Loam	ML or OL
		27–52	Loam	ML
Wadena (WaA, WaB, WaC2)	10+	0–10	Loam	SM or SC
		10–24	Loam	SC or SM–SC
		24–50	Sand and gravel	SP or GP
Webster (Cw)	1–4	0–14	Silty clay loam	MH or OH
		14–20	Clay loam	CL
		20–36	Clay loam	CL

[1] Estimates based on textural class and organic-matter content.
[2] Variable.
[3] Unclassified.

properties—Continued

Classification—Continued	Percentage passing sieve—			Permeability	Available water capacity [1]	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
				In. per hr.	*In. per in. of soil*	*pH*	
A–4	95–100	95–100	50–70	0. 6–2. 0	. 20	6. 1–6. 5	Moderate.
A–4	95–100	95–100	50–70	0. 6–2. 0	. 18	5. 1–6. 5	Moderate.
A–7	95–100	95–100	70–85	0. 2–0. 6	. 18	5. 1–6. 5	High.
A–3 or A–1	75–90	60–100	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A–2	95–100	95–100	20–30	2. 0–6. 3	. 12	6. 1–6. 5	Low.
A–7	95–100	95–100	70–85	0. 2–0. 6	. 18	5. 1–6. 5	High.
A–2	95–100	95–100	10–15	6. 3+	. 03	5. 1–6. 5	Low.
A–3 or A–1	75–90	60–100	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A–6 or A–7	95–100	95–100	55–75	2. 0–6. 3	. 20	6. 1–6. 5	Moderate.
A–6	95–100	95–100	55–80	0. 6–2. 0	. 17	5. 1–6. 5	Moderate to high.
A–6	95–100	90–100	55–70	0. 6–2. 0	. 17	7. 4–7. 8	Moderate.
A–7	95–100	95–100	65–80	0. 6–2. 0	. 20	6. 1–6. 5	Moderate to high.
A–7	95–100	95–100	70–85	0. 6–2. 0	. 18	5. 1–6. 0	High.
A–6	95–100	95–100	55–70	0. 6–2. 0	. 17	7. 4–7. 8	Moderate to high.
A–4	95–100	90–100	45–60	0. 6–2. 0	. 20	7. 4–7. 8	Low to moderate.
A–4	95–100	90–100	35–55	0. 6–2. 0	. 17	7. 4–7. 8	Low to moderate.
A–1	45–90	45–80	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A–7	95–100	95–100	80–90	0. 2–0. 6	. 25	7. 4–7. 8	High.
A–8	----------	----------	----------	[2]	. 50	[5] 7. 4–7. 8	Moderate to high.
A–2	95–100	95–100	15–30	6. 3+	. 08	5. 6–6. 5	Low.
A–2	95–100	95–100	20–35	6. 3+	. 08	5. 6–6. 5	Low.
A–2	95–100	75–95	5–25	6. 3+	. 03	5. 6–6. 5	Low.
A–2 or A–1	80–90	65–80	10–20	6. 3+	. 04	6. 1–7. 3	Low.
A–1	35–60	25–40	2–5	6. 3+	. 02	7. 4–7. 8	Low.
A–2	55–95	50–90	10–20	6. 3+	. 07	6. 1–7. 3	Low.
[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2].
A–4	95–100	95–100	55–70	0. 6–2. 0	. 20	7. 4–7. 8	Moderate.
A–6	95–100	85–95	55–70	0. 6–2. 0	. 17	7. 4–7. 8	Moderate.
A–7	95–100	95–100	80–90	0. 2–0. 6	. 25	7. 4–7. 8	Moderate to high.
A–7	95–100	70–90	75–85	0. 2–0. 6	. 18	7. 4–7. 8	Moderate to high.
A–2	90–100	80–90	20–30	6. 3+	. 07	7. 4–7. 8	Low.
A–1 or A–3	45–70	30–40	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A–4	95–100	90–100	55–65	0. 6–2. 0	. 20	5. 6–7. 3	Moderate.
A–6	95–100	90–100	55–70	0. 6–2. 0	. 17	5. 6–7. 3	Moderate to high.
A–4	95–100	95–100	55–75	0. 6–2. 0	. 20	5. 6–7. 3	Moderate.
A–4	95–100	95–100	55–75	0. 6–2. 0	. 17	5. 6–7. 3	Moderate.
A–4	95–100	90–100	45–50	2. 0–6. 3	. 20	6. 1–7. 3	Low to moderate.
A–4	95–100	90–100	45–50	2. 0–6. 3	. 17	6. 1–7. 3	Low to moderate.
A–1 to A–3	45–70	70–95	2–5	6. 3+	. 01	7. 4–7. 8	Low.
A–7	95–100	95–100	70–90	0. 2–0. 6	. 25	6. 1–7. 3	Moderate to high.
A–7	95–100	95–100	70–95	0. 2–0. 6	. 20	6. 1–7. 3	Moderate to high.
A–6	95–100	90–100	55–75	0. 2–0. 6	. 17	7. 4–7. 8	Moderate to high.

[4] For Pc only. Depth varies for Pd, Pm, and Ps.
[5] For Pc only. pH is 6.1 to 7.3 for Pd, Pm, and Ps.

TABLE 5.—*Engineering*

[Engineers and others should not apply specific values to

Soil and map symbol	Suitability as source of—				Soil features affecting—
	Topsoil [1]	Sand [2]	Gravel	Road fill [3]	Highway location
Alluvial land (Al)	Fair to good. Check each site.	Not suitable	Not suitable	Poor to good: variable soil texture. Check each site.	Occasional flooding; high water table; moderate to high susceptibility to frost action.
Alluvial land, frequently flooded (Au).	Variable. Check each site.	Not suitable	Not suitable	Poor to fair: variable soil texture. Check each site.	Frequent flooding; high water table; moderate to high susceptibility to frost action.
Biscay: Loam (Bc)	Good	Fair to good below a depth of 4 feet: stratified coarse sand and fine gravel; high water table.	Possible source below a depth of 4 feet: stratified coarse sand and fine gravel; high water table.	Good below a depth of 4 feet: high water table; good compaction characteristics; good shear strength.	High water table; moderate susceptibility to frost action; erodible where exposed on embankments.
Loam, sandy subsoil variant (Bd).	Good	Possible source below a depth of 4 feet: generally poorly graded sand; layers of gravel in places; high water table.	Not generally suitable: gravel too fine.	Fair to good below a depth of 4 feet: high water table; fair to good compaction characteristics; fair to good shear strength.	High water table; moderate susceptibility to frost action; erodible where exposed on embankments.
Burnsville (BhB, BhC, BuD, BuE). For properties of Hayden soils in mapping units BhB, BhC, BuD, and BuE, refer to Hayden soils.	Fair	Not suitable	Good: sand pockets, stones, boulders, and cobblestones in places.	Very good: excellent shear strength; good compaction characteristics; good bearing capacity; good stability; in places stones, boulders, or cobblestones interfere with grading.	Good drainage; good stability; low susceptibility to frost action; large boulders in some areas.
Canisteo: Silty clay loam (Ca).	Good	Not suitable	Not suitable	Not suitable in uppermost 2 feet because of high plasticity and high organic-matter content; fair in substratum; moderate to high volume change.	High water table; high susceptibility to frost action; poor bearing strength; plastic subsoil.
Silty clay loam, depressional (Cd).	Good: difficult to excavate and handle because of high water table.	Not suitable	Not suitable	Poor: high organic-matter content; high water content; moderate to high volume change; poor shear strength.	High water table; seasonal ponding; high susceptibility to frost action.

See footnotes at end of table.

interpretations

the estimates given for bearing capacity of soils]

Soil features affecting—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment[3]				
Variable soil texture; flooding. Check each site.	Variable soil texture. Check each site.	Drainage not needed.	Flood control needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Variable soil texture; frequent flooding. Check each site.	Variable soil texture. Check each site.	Frequent flooding; drainage not advisable.	Generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Fluctuating water table; features favorable for dug ponds.	Adequate strength and fair stability; good compaction characteristics; pervious if compacted; good resistance to piping.	Caving or sloughing of substratum makes installation and maintenance of tile difficult; drainage needed.	High water table; drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Fluctuating water table; features favorable for dug ponds.	Fair stability; fair to good compaction characteristics; pervious if compacted; fair to poor resistance to piping.	Caving or sloughing of sandy substratum makes installation and maintenance of tile difficult; drainage needed.	High water table; drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Features unfavorable: pervious substratum.	Very stable; good compaction characteristics; pervious if compacted; fair to poor resistance to piping.	Drainage not needed.	Low moisture-holding capacity; shallow root zone; moderate to rapid intake.	Shallow over gravel and sand; stones and boulders in places; irregular slopes; moderately rapid permeability.	Droughty; difficult to establish sod.
Fluctuating water table; moderately slow permeability; features favorable for dug ponds.	Fair to good compaction characteristics; slow permeability if compacted; reasonably stable.	Moderately slow permeability; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Drainage needed before construction of waterway.
High water table; moderately slow permeability; features favorable for dug ponds.	Fair to good stability below a depth of 2 feet; fair to good compaction characteristics; slow permeability if compacted.	Moderately slow permeability; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.

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TABLE 5.—*Engineering*

Soil and map symbol	Suitability as source of—				Soil features affecting—
	Topsoil [1]	Sand [2]	Gravel	Road fill [3]	Highway location
Chaska (Ch)	Good	Not suitable	Not suitable	Poor: high organic-matter content; high water content; moderate to high volume change; fair shear strength.	Flooding; high water table; high susceptibility to frost action.
Comfrey: Silty clay loam (Cm).	Good	Not suitable	Not suitable	Poor: high organic-matter content; high water content; moderate to high volume change; poor shear strength.	Occasional flooding; high water table; high susceptibility to frost action.
Silty clay loam, frequently flooded (Co).	Good: difficult to excavate and handle because of high water table.	Not suitable	Not suitable	Poor: high organic-matter content; high water content; moderate to high volume change; poor shear strength.	Frequent flooding; high water table; high susceptibility to frost action.
Cordova (Cs, Cw) For properties of Webster soils in mapping unit Cw, refer to Webster soils.	Good	Not suitable	Not suitable	Poor in uppermost 3 feet, fair to good in substratum: moderate to high volume change; high water content in places.	High water table; high susceptibility to frost action; poor to fair stability.
Dakota (DrA, DrB) For properties of Rasset soils in mapping unit DrA and DrB, refer to Rasset soils.	Fair to good	Possible source of poorly graded sand. Check each site.	Generally not suitable; possible source of fine gravel. Check each site.	Fair to good: low volume change; good shear strength; low compressibility; fair compaction characteristics.	Good drainage; low susceptibility to frost action; fair to good stability.
Estherville (EsA, EsB, EsB2, EsC, EsC2, EsD, EsE).	Fair to good	Good: stratified, well-graded sand and gravel.	Good: stratified, well-graded sand and gravel.	Good: good stability; good shear strength; good bearing capacity; good compaction characteristics.	Good drainage; very stable; good shear strength; low susceptibility to frost action.
Fairhaven: Silt loam, deep variant (FhA).	Good	Good: poorly graded sand.	Generally not suitable: layers of gravel in places. Check each site.	Good below a depth of 4 feet: good shear strength; low volume change; good bearing capacity; low compressibility.	Good drainage; fair stability; moderate susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment [3]				
Flooding; high water table; moderately slow permeability.	Poor stability; pervious if compacted; poor resistance to piping.	Few suitable outlets; moderately slow permeability; drainage needed; flood prevention needed.	Drainage needed; flood control needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
High water table; moderately slow permeability; occasional flooding; features favorable for dug ponds.	Poor stability; poor compaction characteristics; moderate to slow permeability if compacted; fair to poor resistance to piping.	Few suitable outlets; moderately slow permeability; flood prevention needed; drainage needed.	Drainage needed; flood control needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Frequent flooding; high water table; moderately slow permeability.	Poor stability; poor compaction characteristics; moderate to slow permeability if compacted; fair to poor resistance to piping.	Few suitable outlets; moderately slow permeability; flood prevention needed; drainage needed.	Drainage needed; flood control needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Fluctuating water table; moderately slow permeability; features favorable for dug ponds.	Slow permeability if compacted; good stability; good to fair resistance to piping.	Moderately slow permeability; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Drainage needed before construction of waterway.
Features unfavorable: too porous to hold water; rapid to very rapid permeability below a depth of 3 feet.	Fair stability; rapid permeability if compacted; fair to poor resistance to piping.	Drainage not needed.	Features favorable: rapid intake; rapid permeability; low moisture-holding capacity.	Sand and gravel within a depth of 2 to 3 feet; moderately rapid permeability. Check each site for soil depth and texture.	Erodible; droughty. Design for low velocity.
Features unfavorable: material too porous to hold water; rapid to very rapid permeability below a depth of 2 feet.	Very stable; rapid permeability if compacted; good resistance to piping.	Drainage not needed.	Features favorable: rapid intake; rapid permeability; low moisture-holding capacity.	Shallow over sand and gravel; stones and boulders in some areas; moderately rapid to rapid permeability.	Droughty; difficult to establish vegetation.
Features unfavorable: material too porous to hold water; rapid to very rapid permeability below a depth of 4 feet.	Fair stability; rapid permeability if compacted; low compressibility; piping hazard.	Drainage not needed.	Features favorable: moderately high moisture-holding capacity; high natural fertility; moderately rapid permeability.	Sand substratum within a depth of 4 feet; moderately rapid permeability. Check each site.	Erodible. Design for low velocity.

TABLE 5.—*Engineering*

Soil and map symbol	Suitability as source of—				Soil features affecting—
	Topsoil [1]	Sand [2]	Gravel	Road fill [3]	Highway location
Fairhaven—Continued Silt loam, sand substratum (FaA, FaB, FaC2).	Good	Good: poorly graded sand.	Generally not suitable: layers of gravel in places. Check each site.	Good below a depth of 3 feet: good shear strength; low volume change; good bearing capacity; low compressibility.	Good drainage; fair stability; moderate susceptibility to frost action.
Glencoe (Ge)	Good: difficult to excavate and handle because of high water table.	Not suitable	Not suitable	Poor: highly organic peat and muck surface soil; high water table; moderate to high volume change; poor to fair stability.	High water table; seasonal ponding; low bearing capacity; high compressibility; high susceptibility to frost action.
Hayden (HaB, HaB2, HaC, HaC2, HaD, HaD2, HaE2, HaF, HcC3, HcD3, HcE3).	Fair	Not suitable	Not suitable	Fair: moderate to high volume change; fair to good compaction characteristics; fair shear strength; medium compressibility; good to fair workability.	Good drainage; moderate to high volume change; fair to good bearing capacity; moderate to high susceptibility to frost action.
Hubbard: Loamy sand (HdA, HdB, HdC, HdD, HdF).	Poor	Good: poorly graded sand.	Not suitable	Fair: erodible; fair compaction characteristics; good shear strength; fair stability; low volume change.	Good drainage; fair stability; good shear strength; low susceptibility to frost action.
Sandy loam (HuA, HuB2, HuC2, HuD).	Fair	Good: poorly graded sand.	Not suitable	Fair: erodible; fair compaction characteristics; good shear strength; fair stability; low volume change.	Good drainage; fair stability; good shear strength; low susceptibility to frost action.
Kasota: Loam (KaA, KaB2, KsA, KsB2).	Good	Good: stratified sand and gravel.	Generally not suitable: stratified sand and gravel; possible source of fine gravel.	Good below a depth of 4 feet: good shear strength; low volume change; fair workability; fair compaction characteristics.	Good drainage; fair stability; moderate susceptibility to frost action.
Lester (LaB, LaB2, LaC, LaC2, LaD2, LeB, LeC2). For properties of Estherville soils in mapping units LeB and LeC2, refer to Estherville soils.	Good	Not suitable	Not suitable	Fair: fair shear strength; moderate to high volume change; fair to good compaction characteristics; medium to high compressibility.	Good drainage; fair bearing capacity; fair shear strength; moderate to high susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment [3]				
Features unfavorable: material too porous to hold water; rapid to very rapid permeability below a depth of 3 feet.	Fair stability; permeable if compacted; low compressibility; piping hazard.	Drainage not needed.	Features favorable: moderate moisture-holding capacity; high natural fertility; moderately rapid permeability.	Sand substratum within a depth of 2 to 3 feet; moderately rapid permeability. Check each site.	Erodible. Design for low velocity.
High water table; moderately slow permeability; features favorable for dug ponds.	Fair stability; high water content; slow permeability if compacted; fair to good resistance to piping.	Moderately slow permeability; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Reservoir bottoms semipervious to impervious if scarified and compacted; moderate permeability.	Fair to good stability; fair to good compaction characteristics; slow to moderate permeability if compacted; good to fair resistance to piping.	Drainage not needed.	Features favorable: slow intake if eroded; moderate permeability.	Irregular slopes; features favorable where slope is less than 12 percent.	Erodible. Design for low velocity.
Features unfavorable: very porous; rapid permeability.	Poor stability; poor resistance to piping.	Drainage not needed.	Features favorable: very low moisture-holding capacity; rapid intake; rapid permeability.	Rapid permeability; sand substratum; difficult to establish vegetation.	Very droughty; difficult to establish vegetation and to hold sod.
Features unfavorable: very porous; rapid permeability.	Poor stability; poor resistance to piping.	Drainage not needed.	Features favorable: low moisture-holding capacity; rapid intake; rapid permeability.	Rapid permeability; sand substratum; difficult to establish vegetation.	Droughty; difficult to establish vegetation.
Features unfavorable: pervious substratum; rapid to very rapid permeability below a depth of 3 to 4 feet.	Fair to poor stability in uppermost 3 feet; fair to poor compaction characteristics; fair stability and good compaction characteristics below a depth of 3 feet; fair to poor resistance to piping.	Drainage not needed.	Features favorable: moderately high moisture-holding capacity; high natural fertility; moderate to moderately slow permeability.	Sand and gravel within a depth of 2 to 3 feet. Check each site.	Erodible. Design for low velocity.
Semipervious if scarified and compacted; moderate permeability.	Fair to good stability; fair to good compaction characteristics; slow to moderate permeability if compacted; fair to good resistance to piping.	Drainage not needed.	Features favorable: moderate permeability; slow intake if eroded.	Irregular slopes; features favorable where slope is less than 12 percent.	Erodible. Design for low velocity.

TABLE 5.—*Engineering*

Soil and map symbol	Suitability as source of—				Soil features affecting—
	Topsoil [1]	Sand [2]	Gravel	Road fill [3]	Highway location
LeSueur (LsA, LsB)	Good	Not suitable	Not suitable	Fair to poor: moderate to high volume change; fair shear strength; fair stability.	Moderately high water table; plastic subsoil; high susceptibility to frost action.
Marsh (Ma).[4]					
Mayer (My)	Good	Possible source: stratified, well-graded sand and gravel; high water table.	Possible source: stratified sand and gravel; high water table.	Good below a depth of 3 feet: low volume change; good shear strength; fair to good compaction characteristics.	High water table; moderate to high susceptibility to frost action.
Oshawa (Os)	Good: difficult to excavate and handle because of wetness.	Not suitable	Not suitable	Poor: high organic-matter content; high water content; high volume change; poor shear strength; poor compaction characteristics.	Frequent flooding; high water table; high susceptibility to frost action.
Peat and muck (Pc, Pd, Pm, Ps).	Not suitable	Not suitable	Not suitable	Not suitable	High water table; high susceptibility to frost action. Remove layers of peat and muck.
Rasset (RaB, RaC, RaD).	Fair	Fair to good: poorly graded sand. Check each site.	Poor: mainly sand; a few layers of gravel.	Good: good shear strength; low volume change; fair to good stability.	Good drainage; good bearing capacity; low susceptibility to frost action.
Salida (SaF)	Not suitable	Good: stratified sand and gravel.	Good: stratified sand and gravel.	Good: good shear strength; low volume change; good compaction characteristics.	Good drainage; good stability; good shear strength; low susceptibility to frost action.
Sandy colluvial land (Sc).	Not suitable	Possible source of poorly graded sand. Check each site.	Possible source. Check each site.	Fair to good: low volume change; fair to good shear strength; good compaction characteristics.	Possible seepage; low susceptibility to frost action.
Sandy lake beaches (Sk).	Not suitable	Poor to good: high water table. Check each site.	Poor to good: high water table. Check each site.	Poor to good: high water table. Check each site.	High water table; areas near lakes submerged in some wet years; moderate to high susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment [3]				
Moderately high water table; moderate permeability; features favorable for dug ponds.	Poor stability in uppermost 3 feet; reasonable stability in substratum; slow permeability if compacted; good to fair resistance to piping.	Drainage generally not needed.	Features favorable: generally not irrigated.	Terraces and diversions generally not used.	Features favorable.
Fluctuating water table; features favorable for dug ponds.	Adequate strength and fair stability; good compaction characteristics; good resistance to piping.	Caving and sloughing of sandy and gravelly substratum; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Frequent flooding; high water table.	High organic-matter content; high water content; fair to poor stability; fair to poor resistance to piping.	Frequent flooding; drainage needed.	Flood protection needed; drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Features favorable: high water table. Check depth of peat and muck and type of underlying material.	Highly organic soil; features unfavorable.	Drainage needed but not advisable for peat and muck, moderately shallow, over sand.	Drainage needed	Terraces and diversions not needed.	Waterways generally not used.
Features unfavorable: porous; rapid permeability.	Fair to good stability; fair resistance to piping.	Drainage not needed.	Features favorable: rapid intake; low moisture-holding capacity; low natural fertility.	Sand substratum; rapid intake. Check each site.	Droughty; difficult to establish vegetation.
Features unfavorable: too porous to hold water; very rapid permeability.	Good stability; fair resistance to piping.	Drainage not needed.	Very low moisture-holding capacity; very low natural fertility; rapid intake.	Rapid intake; terraces and diversions generally not needed.	Very droughty; difficult to establish vegetation.
Features unfavorable: very porous; rapid permeability.	Fair stability; fair to good compaction characteristics; poor resistance to piping.	Drainage not needed.	Low moisture-holding capacity; rapid intake; rapid permeability; low natural fertility.	Rapid intake; terraces and diversions generally not needed.	Very droughty; difficult to establish sod.
Fluctuating water table; rapid permeability.	Variable texture. Check each site.	Generally not drained. Check each site.	Generally not irrigated. Check each site.	Terraces and diversions not needed.	Waterways generally not used.

TABLE 5.—*Engineering*

Soil and map symbol	Suitability as source of—				Soil features affecting—
	Topsoil [1]	Sand [2]	Gravel	Road fill [3]	Highway location
Storden (SIC2, SID2)—For properties of Lester soils in mapping units SIC2 and SID2, refer to Lester soils.	Poor: very shallow surface soil.	Not suitable	Not suitable	Fair to good: fair shear strength; moderate volume change; fair to good compaction characteristics.	Good drainage; fair shear strength; moderate to high susceptibility to frost action.
Talcot (Ta)	Good: difficult to excavate and handle because of high water table.	Poor: high water table; stratified sand and gravel.	Poor: high water table; stratified sand and gravel.	Poor in uppermost 3 feet because of high organic-matter content and high water content; stratified sand and gravel below a depth of 4 feet; excavation difficult because of high water table.	Frequent ponding; high water table; high organic-matter content; high susceptibility to frost action.
Terril:					
Loam (TeB, TeC)	Good	Not suitable	Not suitable	Fair to poor: fair shear strength; moderate to high volume change; fair to good compaction characteristics.	Moderately high water table; possible sidehill seepage; high susceptibility to frost action.
Loam, occasionally flooded (To).	Good	Not suitable	Not suitable	Fair: fair compaction characteristics; fair stability; moderate to fair shear strength; occasional flooding.	Occasional flooding; moderately high water table; moderate susceptibility to frost action.
Wadena (WaA, WaB, WaC2).	Good	Good: stratified sand and gravel.	Good: stratified sand and gravel.	Good below a depth of 3 feet: good shear strength; low volume change; good bearing capacity; good compaction characteristics.	Good drainage; very stable; good shear strength; low compressibility; good compaction characteristics.
Webster (Cw)	Good	Not suitable	Not suitable	Poor in uppermost 3 feet but fair to good in substratum; moderate to high volume change; high water content in places.	High water table; high susceptibility to frost action; poor to fair stability.

[1] Refers to surface layer only.
[2] Poorly graded sand is sand of uniform particle size. Well-graded sand is a mixture of sand of all particle sizes in approximately equal proportions.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment [3]				
Semipervious if scarified and compacted; moderate permeability.	Fair to good stability; fair to good compaction characteristics; slow permeability if compacted; good to fair resistance to piping.	Drainage not needed.	Very slow infiltration rate; moderate permeability; generally not irrigated because of rolling to steep slopes.	Terraces and diversions difficult to construct because of irregular slopes.	Erodible. Design for low velocity.
High water table; features favorable for dug ponds.	Features unfavorable in uppermost 3 feet because of high organic-matter content and high water content; good stability and compaction characteristics below a depth of 3 feet; fair to good resistance to piping.	Caving and sloughing of sandy and gravelly substratum; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Waterways generally not used.
Moderately high water table; moderate permeability; features generally favorable for dug ponds on level topography.	Fair to good compaction characteristics; slow to moderate permeability if compacted; good to fair resistance to piping.	Moderately well drained; drainage generally not needed.	Moderately high water table; high moisture-holding capacity; moderate permeability; generally not irrigated.	Terraces and diversions not needed.	Features favorable.
Occasional flooding; moderately high water table.	Fair stability; fair compaction characteristics; fair to poor resistance to piping.	Drainage not needed.	Features favorable: occasional flooding.	Terraces and diversions not needed.	Waterways generally not used.
Features unfavorable: very permeable substratum.	Fair stability; fair to poor resistance to piping in uppermost 3 feet; substratum stable.	Drainage not needed.	Features favorable: moderate moisture-holding capacity; high natural fertility.	Sand and gravel within a depth of 2 to 3 feet.	Erodible. Design for low velocity.
Fluctuating water table; moderately slow permeability; features favorable for dug ponds.	Slow permeability if compacted; good stability; good to fair resistence to piping.	Moderately slow permeability; drainage needed.	Drainage needed; generally not irrigated.	Terraces and diversions not needed.	Drainage needed before construction of waterways.

[3] Refers to the underlying material, or substratum, unless otherwise specified.
[4] No interpretations provided. Check each site.

The Fairhaven, Kasota, and Wadena soils are good for crops. The rest are droughty and are only fairly good to poor for crops.

These soils have only slight limitations as locations for residences, stores, factories, schools, and similar facilities. Many occur as fairly broad flats suitable for shopping centers.

Limitations for use as foundations of buildings of three stories or less are slight. The substratum has good bearing capacity, good shear strength, low susceptibility to frost action, and low shrink-swell potential. Except for a few large stones in Estherville soils, there are no serious problems in grading and excavating. Controlling erosion is likely to be a problem on slopes of more than 2 percent if the vegetative cover is removed.

Limitations for use as septic tank filter fields are slight. The soils are permeable and absorb sewage fairly rapidly. Preventing contamination of nearby water supplies is a problem, because a gravelly substratum permits unfiltered sewage to travel a long distance. Percolation tests of Dakota and Rasset soils are needed, because in places the substratum contains clayey layers, which impede the flow of sewage.

Establishing grass sod on Fairhaven, Kasota, and Wadena soils is easy. The rest of the soils in this group are sandy and droughty and need to be topdressed with loamy material before they are seeded or sodded.

Building site group 2

This group consists of soils of the Estherville, Fairhaven, Hubbard, Rasset, and Wadena series. These soils are excessively drained to well drained. The slope range is 6 to 12 percent. The texture of the surface layer ranges from loamy sand to silt loam. All of these soils are underlain by sand or gravel, or both, within a depth of 3½ feet. They do not have a seasonal high water table. Water moves rapidly to very rapidly in the coarse-textured substratum.

The soils in this group are droughty and susceptible to erosion. They are poor to fair for crops.

These soils have moderate limitations as locations for residences and stores, but they generally occur as areas too small for shopping centers, factories, schools, and similar facilities.

Limitations for use as foundations of buildings of no more than three stories are moderate. The substratum has good bearing capacity, good shear strength, low susceptibility to frost action, and low shrink-swell potential. The slope does not interfere seriously with construction. Except for a few large stones in Estherville soils, there are no serious limitations in grading and excavating. Erosion is severe in areas where the vegetative cover is removed.

Limitations for use as septic tank filter fields are moderate. The soils are permeable, absorb sewage fairly rapidly, and do not have a seasonal high water table. Preventing contamination of nearby water supplies is a problem, because a gravelly substratum permits unfiltered sewage to travel a long distance. Percolation tests of Rasset soils are needed, because in places the substratum contains clayey layers, which impede the flow of sewage.

Establishing grass sod on Fairhaven and Wadena soils is easy. The rest of the soils in this group are sandy and droughty and need to be topdressed with loamy material before they are seeded or sodded.

Building site group 3

This group consists of soils of the Estherville, Hubbard, Rasset, and Salida series. These soils are excessively drained to somewhat excessively drained. The slope range is 12 to 40 percent. The texture of the surface layer ranges from loamy sand to sandy loam. All of these soils are underlain by sand or gravel, or both, within a depth of 2 feet. The water table is very low. Water moves rapidly to very rapidly in the coarse-textured substratum.

The soils in this group are too steep and too droughty to be suitable for crops.

These soils have moderate to severe limitations as locations for stores, schools, factories, or hospitals. They are suitable for residences where the slope is less than 12 percent, but construction operations and accessibility are moderately to severely limited where the slope is more than 12 percent.

Limitations for use as foundations of buildings of no more than three stories are moderate to severe. The substratum has good bearing capacity, good shear strength, low susceptibility to frost action, and low shrink-swell potential. Except for a few large stones in Estherville soils, there are no serious limitations in grading and excavating. Soil creep is a hazard where the slope is more than 18 percent. Precautions are needed during and after construction because erosion is generally severe and is likely to damage property in lower lying areas.

Limitations for use as septic tank filter fields are severe. The soils have good internal drainage and absorb water and sewage fairly rapidly, but the slope makes seepage beds impractical and makes it difficult to lay out and construct trench filter fields for septic tanks. Downslope pollution is a hazard. Preventing contamination of nearby water supplies is a problem, because a gravelly substratum permits sewage to travel a long distance.

Establishing shrubs and good lawns is difficult. The soils are droughty and need to be topdressed with 6 to 12 inches of loamy material before they are seeded or sodded. Establishing vegetation is particularly difficult on the very shallow Salida soils.

Building site group 4

This group consists of soils of the Hayden and Lester series and soils of the Burnsville-Hayden complex and the Lester-Estherville complex. These soils are loamy, deep, and well drained. They do not have a seasonal high water table and are not subject to flooding. The slope range is 2 to 6 percent.

The soils in this group are among the best in the county for crops.

These soils have only slight limitations as locations for residences, stores, factories, schools, and similar facilities.

Limitations for use as foundations of buildings of no more than three stories are slight to moderate. The substratum has fair to good bearing capacity, fair shear strength, moderate susceptibility to frost action, and moderate shrink-swell potential. Except for a few large stones and boulders in soils of the Burnsville-Hayden complex and the Lester-Estherville complex, there are no serious limitations in grading and excavating. Erosion is likely to be severe if the vegetative cover is removed.

Limitations for use as septic tank filter fields are moderate.

The soils are only moderately permeable, and sewage moves slowly through the substratum. Percolation tests are needed.

It is easy to establish trees, shrubs, grass, and sod on these soils.

Building site group 5

This group consists of soils of the Hayden and Lester series, soils of the Burnsville-Hayden complex and the Lester-Estherville complex, and Storden-Lester loams. These soils are loamy, deep, and well drained. The slope range is 6 to 12 percent. The water table is at a depth of more than 10 feet.

The soils of this group are fairly good for crops, but they are highly susceptible to erosion.

These soils have moderate limitations as locations for residences and stores, but they occur as areas too small for shopping centers, factories, schools, and similar facilities. The slope does not interfere seriously with construction, but it increases the cost of construction. Erosion is serious if the vegetative cover is removed.

Limitations for use as foundations of buildings of no more than three stories are moderate. The substratum has good to fair bearing capacity, fair shear strength, moderate susceptibility to frost action, and moderate shrink-swell potential. Except for a few large stones in soils of the Burnsville-Hayden complex and the Lester-Estherville complex, there are no serious limitations in grading and excavating.

Limitations for use as septic tank filter fields are moderate to severe. The soils are only moderately permeable, and sewage moves slowly through the substratum. Percolation tests are needed.

It is easy to establish trees, shrubs, grass, and sod on these soils.

Building site group 6

This group consists of Burnsville-Hayden sandy loams, Storden-Lester loams, and other soils of the Hayden and Lester series. All of these soils are loamy, deep, and well drained. The slope range is 12 to 18 percent. The water table is at a depth of more than 10 feet.

The soils of this group can be used only occasionally for crops, because they are highly susceptible to erosion.

These soils have severe limitations as locations for residences but are too steep to be suitable for stores, factories, schools, and similar facilities. The slope not only interferes with construction operations and accessibility but also increases the cost of excavating and grading and the cost of the building design.

Limitations for use as foundations of buildings of no more than three stories are moderate. The substratum has good to fair bearing capacity, fair shear strength, moderate susceptibility to frost action, and moderate shrink-swell potential. Except for a few large stones in Burnsville-Hayden sandy loams, there are no serious limitations in grading and excavating. Erosion is severe unless precautions are taken during and after construction.

Limitations for use as septic tank filter fields are severe. The soils are only moderately permeable, and sewage moves slowly through the substratum. Because of the slope, laying out trench filter fields is difficult and expensive. Percolation tests are needed.

It is easy to establish trees, shrubs, and sod on these soils, but rapid runoff makes it difficult to establish grass seedings unless a straw mulch is used.

Building site group 7

This group consists of Burnsville-Hayden sandy loams and other soils of the Hayden series. These soils are loamy, deep, and well drained. The slope range is 18 to 40 percent. The water table is at a depth of more than 10 feet.

The soils of this group are unsuitable for crops and are only fair for pasture.

These soils have severe limitations as locations for shopping centers, factories, schools, and similar facilities. They are suitable only for residences. The slope not only interferes seriously with accessibility and construction operations, but also increases the cost of the building design and the cost of excavating and grading.

Limitations for use as foundations of buildings of no more than three stories are severe. The substratum has good to fair bearing capacity, fair shear strength, moderate susceptibility to frost action, and moderate to high shrink-swell potential. Except for a few large stones in Burnsville-Hayden sandy loams, there are no serious limitations in grading and excavating. Erosion is a hazard both during and after construction.

Limitations for use as septic tank filter fields are severe. The soils are only moderately permeable, and because of the slope, laying out trench filter fields is expensive and difficult. Downslope pollution is a hazard. Percolation tests are needed.

It is easy to establish sod, trees, and shrubs on these soils, but rapid runoff makes it difficult to establish grass seedings unless a straw mulch is used.

Many areas of these soils are wooded and are close to lakes and streams. They are desirable sites for parks, picnic areas, and campsites and can be developed and used for hunting, fishing, skiing, tobogganing, and other sports.

Building site group 8

This group consists of Sandy colluvial land and soils of the LeSueur and Terril series. These soils are moderately well drained and medium textured to moderately fine textured. The gradient is generally less than 5 percent but ranges from 0 to 12 percent. The seasonal high water table is at a depth of 2 to 4 feet. The soils in this group are among the best in the county for crops.

Because of the water table, these soils have moderate to severe limitations as locations for residential and commercial developments. If they are to be used as building sites, artificial drainage is needed, and fill is needed to keep the foundation above the waterline. Unless well surfaced, these soils have poor trafficability if used as roads. Moreover, Terril soils are subject to sidehill seepage.

Limitations for use as foundations of buildings of no more than three stories are moderate. The substratum has fair bearing capacity, fair shear strength, moderate to high susceptibility to frost action, and low to moderately high shrink-swell potential.

Limitations for use as septic tank filter fields are severe. The water table is high, and permeability is moderate to moderately slow.

It is easy to establish grass, sod, trees, and shrubs on these soils.

Building site group 9

This group consists of soils of the Biscay, Canisteo, Cordova, Mayer, and Webster series. These soils are poorly drained and medium textured to moderately fine textured. The slope range is 0 to 2 percent. The seasonal high water table is at a depth of 1 to 3 feet. Drained areas are very good for crops.

Because of wetness, these soils have severe limitations as locations for residential and commercial developments. If they are to be used as building sites, artificial drainage is needed, and fill is needed to keep the foundation above the waterline. These soils are sticky when wet and have poor trafficability if used as roads.

Limitations for use as foundations of buildings of no more than three stories are severe. The substratum has fair to poor bearing capacity, fair to poor shear strength, high susceptibility to frost action, and low to high shrink-swell potential.

Limitations for use as septic tank filter fields are severe. The water table is high, and permeability is moderate to moderately slow.

It is easy to establish grass, sod, trees, and shrubs on these soils.

Building site group 10

This group consists of Sandy lake beaches, Marsh, Peat and muck, and soils of the Canisteo, Glencoe, and Talcot series. All are poorly drained and very poorly drained soils in depressions. Unless artificially drained, they are seasonally ponded. The water table is within a depth of 1 foot.

Drained areas are good for crops. Undrained areas are fair for wild hay and pasture.

Because of wetness, these soils have very severe limitations for community developments. If they are to be used as building sites, drainage is needed, and fill is needed to keep the foundation above the water line. The peat and muck soil material should be completely removed before the fill is added. These soils have poor trafficability if used as roads.

Limitations for use as foundations of buildings of no more than three stories are very severe. The substratum has poor to fair bearing capacity, poor to fair shear strength, high susceptibility to frost action, and low to high shrink-swell potential.

Limitations for use as septic tank filter fields are severe. The water table is high, and permeability is moderate to moderately slow.

Many areas are suitable for wildlife habitat. Some would be suitable for parks and recreational areas.

Building site group 11

This group consists of Alluvial land and soils of the Chaska, Comfrey, Oshawa, and Terril series. These soils are on flood plains. They vary in frequency of flooding and have a seasonal high water table.

The areas that are seldom flooded are good for crops. Those that are frequently flooded are used mainly for pasture.

These soils have very severe limitations as locations for residences or other buildings unless they are protected from flooding.

Limitations for use as foundations of buildings of no more than three stories are very severe. The substratum has fair to poor bearing capacity, fair to poor shear strength, and low to high shrink-swell potential.

Limitations for use as septic tank filter fields are severe.

These soils would be suitable for parks, recreational areas, and wildlife sanctuaries. Areas that are seldom flooded would be suitable for campsites and picnic areas.

Soils in Recreational Development

The many lakes and streams in Carver County provide ample opportunity for fishing, hunting, swimming, and boating, and the wooded hills and valleys along the Minnesota River and its outlet streams provide ideal sites for picnic areas, campsites, paths, and trails. The information in the following paragraphs and in table 6 can be used as a guide in determining the suitability of sites in Carver County for recreational development.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Alluvial land (Al)	Severe: occasional flooding; seasonal high water table.	Moderate: occasional flooding; seasonal high water table.	Very severe: occasional flooding; seasonal high water table.	Moderate: occasional flooding.	Severe: occasional flooding.
Alluvial land, frequently flooded (Au).	Very severe: frequent flooding; high water table.	Very severe: frequent flooding; high water table.	Very severe: frequent flooding; high water table.	Very severe: frequent flooding; high water table.	Very severe: frequent flooding; high water table.
Biscay loam (Bc)	Severe: poor drainage; high water table; sticky when wet.	Severe: poor drainage; high water table.	Severe: poor drainage; high water table.	Severe: poor drainage; sticky when wet.	Severe: poor drainage; sticky when wet.
Biscay loam, sandy subsoil variant (Bd).	Severe: poor drainage; high water table; sticky when wet.	Severe: poor drainage; high water table.	Severe: poor drainage; high water table.	Severe: poor drainage; sticky when wet.	Severe: poor drainage; sticky when wet.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*—Continued

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Burnsville-Hayden complex, 2 to 6 percent slopes (BhB).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Burnsville-Hayden complex, 6 to 12 percent slopes (BhC).	Severe: slope	Moderate: slope	Moderate: slope	None to slight	Moderate: slope.
Burnsville-Hayden sandy loams, 12 to 18 percent slopes (BuD).	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Burnsville-Hayden sandy loams, 18 to 25 percent slopes (BuE).	Very severe: slope	Severe to very severe: slope.	Severe to very severe: slope.	Severe to very severe: slope.	Severe to very severe: slope.
Canisteo silty clay loam (Ca).	Severe: poor drainage; high water table; slippery and sticky when wet.	Severe: poor drainage; slippery and sticky when wet.	Severe: poor drainage; high water table.	Severe: poor drainage; slippery and sticky when wet.	Severe: poor drainage; slippery and sticky when wet.
Canisteo silty clay loam, depressional (Cd).	Very severe: very poor drainage; seasonal ponding; sticky and slippery when wet.	Very severe: very poor drainage; seasonal ponding; sticky and slippery when wet.	Very severe: very poor drainage; seasonal ponding.	Very severe: very poor drainage; seasonal ponding; sticky and slippery when wet.	Very severe: very poor drainage; seasonal ponding; sticky and slippery when wet.
Chaska silty clay loam (Ch).	Very severe: flooding; poor drainage; high water table; sticky and slippery when wet.	Very severe: flooding; poor drainage; high water table; sticky and slippery when wet.	Very severe: flooding; poor drainage; high water table.	Severe: flooding; poor drainage; sticky and slippery when wet.	Very severe: flooding; poor drainage; sticky and slippery when wet.
Comfrey silty clay loam (Cm).	Very severe: flooding; poor drainage; high water table; sticky and slippery when wet.	Very severe: flooding; poor drainage; high water table; sticky and slippery when wet.	Very severe: flooding; poor drainage; high water table.	Severe: flooding; poor drainage; sticky and slippery when wet.	Very severe: flooding; poor drainage; sticky and slippery when wet.
Comfrey silty clay loam, frequently flooded (Co).	Very severe: frequent flooding; seasonal ponding; high water table; sticky and slippery when wet.	Very severe: frequent flooding; seasonal ponding; high water table.	Very severe: frequent flooding; seasonal ponding; high water table.	Very severe: frequent flooding; seasonal ponding; sticky and slippery when wet.	Very severe: frequent flooding; seasonal ponding; sticky and slippery when wet.
Cordova silty clay loam (Cs).	Severe: poor drainage; high water table; sticky and slippery when wet.	Severe: poor drainage; high water table; sticky and slippery when wet.	Severe: poor drainage; high water table.	Severe: poor drainage; sticky and slippery when wet.	Severe: poor drainage; sticky and slippery when wet.
Cordova and Webster silty clay loams (Cw).	Severe: poor drainage; high water table; sticky and slippery when wet.	Severe: poor drainage; high water table; sticky and slippery when wet.	Severe; poor drainage; high water table.	Severe: poor drainage; sticky and slippery when wet.	Severe: poor drainage; sticky and slippery when wet.
Dakota and Rasset sandy loams, 0 to 2 percent slopes (DrA).	None to slight	None to slight	None to slight	None to slight	None to slight.
Dakota and Rasset sandy loams, 2 to 6 percent slopes (DrB).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*—Continued

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Estherville sandy loam, 0 to 2 percent slopes (EsA).	None to slight	None to slight	None to slight	None to slight	None to slight.
Estherville sandy loam, 2 to 6 percent slopes (EsB).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Estherville sandy loam, 2 to 6 percent slopes, eroded (EsB2).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Estherville sandy loam, 6 to 12 percent slopes (EsC).	Severe: slope	Moderate: slope; severe erosion if vegetative cover is not maintained.	Moderate: slope	None to slight	Moderate: slope.
Estherville sandy loam, 6 to 12 percent slopes, eroded (EsC2).	Severe: slope	Moderate: slope; severe erosion if vegetative cover is not maintained.	Moderate: slope	None to slight	Moderate: slope.
Estherville sandy loam, 12 to 18 percent slopes (EsD).	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Estherville sandy loam, 18 to 25 percent slopes (EsE).	Very severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Fairhaven silt loam, deep variant, 0 to 3 percent slopes (FhA).	Moderate: slippery when wet.	Moderate: slippery when wet.	None to slight	Moderate: slippery when wet.	Moderate: slippery when wet.
Fairhaven silt loam, sand substratum, 0 to 2 percent slopes (FaA).	Moderate: slippery when wet.	Moderate: slippery when wet.	None to slight	Moderate: slippery when wet.	Moderate: slippery when wet.
Fairhaven silt loam, sand substratum, 2 to 6 percent slopes (FaB).	Moderate: slope; slippery when wet.	Moderate: slippery when wet.	None to slight	Moderate: slippery when wet.	Moderate: slippery when wet.
Fairhaven silt loam, sand substratum, 6 to 12 percent slopes, eroded (FaC2).	Severe: slope; slippery when wet.	Moderate: slope; slippery when wet.	Moderate: slope	Moderate: slippery when wet.	Moderate: slope; slippery when wet.
Glencoe silty clay loam (Ge).	Very severe: seasonal ponding; high water table; sticky and slippery when wet.	Very severe: seasonal ponding; high water table; sticky and slippery when wet.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; sticky and slippery when wet.	Very severe: seasonal ponding; high water table; sticky and slippery when wet.
Hayden clay loam, 6 to 12 percent slopes, severely eroded (HcC3).	Severe: slope; sticky when wet.	Moderate: slope; sticky when wet.	Moderate: slope	Moderate: sticky when wet.	Moderate: slope; sticky when wet.
Hayden clay loam, 12 to 18 percent slopes, severely eroded (HcD3).	Severe: slope	Severe: slope; sticky when wet.	Severe: slope	Moderate: slope; sticky when wet.	Severe: slope; sticky when wet.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*—Continued

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Hayden clay loam, 18 to 25 percent slopes, severely eroded (HcE3).	Very severe: slope	Very severe: slope	Severe: slope	Severe: slope; sticky when wet.	Severe: slope; sticky when wet.
Hayden loam, 2 to 6 percent slopes (HaB).	Moderate: slope; sticky when wet.	None to slight: sticky when wet.	None to slight	None to slight: sticky when wet.	None to slight: sticky when wet.
Hayden loam, 2 to 6 percent slopes, eroded (HaB2).	Moderate: slope; sticky when wet.	None to slight: sticky when wet.	None to slight	None to slight: sticky when wet.	None to slight: sticky when wet.
Hayden loam, 6 to 12 percent slopes (HaC).	Severe: slope; sticky when wet.	Moderate: slope; sticky when wet.	Moderate: slope	None to slight: sticky when wet.	Moderate: slope; sticky when wet.
Hayden loam, 6 to 12 percent slopes, eroded (HaC2).	Severe: slope; sticky when wet.	Moderate: slope; sticky when wet.	Moderate: slope	None to slight: sticky when wet.	Moderate: slope; sticky when wet.
Hayden loam, 12 to 18 percent slopes (HaD).	Severe: slope	Severe: slope; sticky when wet.	Severe: slope	Moderate: slope; sticky when wet.	Severe: slope; sticky when wet.
Hayden loam, 12 to 18 percent slopes, eroded (HaD2).	Severe: slope	Severe: slope; sticky when wet.	Severe: slope	Moderate: slope; sticky when wet.	Severe: slope; sticky when wet.
Hayden loam, 18 to 25 percent slopes, eroded (HaE2).	Very severe: slope	Severe: slope	Severe: slope	Severe: slope; sticky when wet.	Severe: slope; sticky when wet.
Hayden loam, 25 to 40 percent slopes (HaF).	Very severe: slope	Very severe: slope	Very severe: slope	Very severe: slope; sticky when wet.	Very severe: slope; sticky when wet.
Hubbard loamy sand, 0 to 2 percent slopes (HdA).	Moderate: loose sandy surface; blowing; difficult to establish vegetation.	Moderate: loose sandy surface; blowing; difficult to establish vegetation.	None to slight	Moderate: loose sandy surface.	Moderate: loose sandy surface; blowing; difficult to establish vegetation.
Hubbard loamy sand, 2 to 6 percent slopes (HdB).	Moderate: slope; loose sandy surface; blowing; difficult to establish vegetation.	Moderate: loose sandy surface; blowing; difficult to establish vegetation.	None to slight	Moderate: loose sandy surface.	Moderate: loose sandy surface; blowing; difficult to establish vegetation.
Hubbard loamy sand, 6 to 12 percent slopes (HdC).	Severe: slope; loose sandy surface; difficult to establish vegetation.	Moderate: slope; loose sandy surface; difficult to establish vegetation.	Moderate: slope	Moderate: loose sandy surface.	Moderate: slope; loose sandy surface; difficult to establish vegetation.
Hubbard loamy sand, 12 to 18 percent slopes (HdD).	Severe: slope; loose sandy surface; difficult to establish vegetation.	Severe: slope; loose sandy surface; difficult to establish vegetation.	Severe: slope	Moderate: slope; loose sandy surface.	Severe: slope; loose sandy surface; difficult to establish vegetation.
Hubbard loamy sand, 18 to 35 percent slopes (HdF).	Severe to very severe: slope; loose sandy surface; difficult to establish vegetation.	Severe to very severe: slope; loose sandy surface; difficult to establish vegetation.	Severe to very severe: slope.	Severe to very severe: slope; loose sandy surface.	Severe to very severe: slope; loose sandy surface; difficult to establish vegetation.
Hubbard sandy loam, 0 to 2 percent slopes (HuA).	None to slight	None to slight	None to slight	None to slight	None to slight.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*—Continued

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Hubbard sandy loam, 2 to 6 percent slopes, eroded (HuB2).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Hubbard sandy loam, 6 to 12 percent slopes, eroded (HuC2).	Severe: slope	Moderate: slope; severe erosion if vegetative cover is not maintained.	Moderate: slope	None to slight	Moderate: slope.
Hubbard sandy loam, 12 to 18 percent slopes (HuD).	Severe: slope	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Kasota loam, 0 to 2 percent slopes (KaA).	None to slight	None to slight	None to slight	None to slight	None to slight.
Kasota loam, 2 to 6 percent slopes, eroded (KaB2).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Kasota sandy loam, 0 to 2 percent slopes (KsA).	None to slight	None to slight	None to slight	None to slight	None to slight.
Kasota sandy loam, 2 to 6 percent slopes, eroded (KsB2).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Lester loam, 2 to 6 percent slopes (LaB).	Moderate: slope	None to slight: sticky when wet.	None to slight	None to slight: sticky when wet.	None to slight: sticky when wet.
Lester loam, 2 to 6 percent slopes, eroded (LaB2).	Moderate: slope	None to slight: sticky when wet.	None to slight	None to slight: sticky when wet.	None to slight: sticky when wet.
Lester loam, 6 to 12 percent slopes (LaC).	Severe: slope	Moderate: slope; sticky when wet.	Moderate: slope	None to slight: sticky when wet.	Moderate: slope; sticky when wet.
Lester loam, 6 to 12 percent slopes, eroded (LaC2).	Severe: slope	Moderate: slope; sticky when wet.	Moderate: slope	None to slight: sticky when wet.	Moderate: slope; sticky when wet.
Lester loam, 12 to 18 percent slopes, eroded (LaD2).	Severe: slope	Severe: slope; sticky when wet.	Severe: slope	Moderate: slope; sticky when wet.	Severe: slope.
Lester-Estherville complex, 2 to 6 percent slopes (LeB).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Lester-Estherville complex, 6 to 12 percent slopes, eroded (LeC2).	Severe: slope	Moderate: slope	Moderate: slope	None to slight	Moderate: slope.
LeSueur clay loam, 0 to 2 percent slopes (LsA).	Moderate: fairly high seasonal water table; sticky and slippery when wet.	Slight to moderate: fairly high seasonal water table; sticky and slippery when wet.	Slight to moderate: fairly high seasonal water table.	Slight to moderate: fairly high seasonal water table; sticky and slippery when wet.	Slight to moderate: fairly high seasonal water table; sticky and slippery when wet.
LeSueur clay loam, 2 to 6 percent slopes (LsB).	Moderate: fairly high seasonal water table; sticky and slippery when wet.	Slight to moderate: fairly high seasonal water table; sticky and slippery when wet.	Slight to moderate: fairly high seasonal water table.	Slight to moderate: fairly high seasonal water table; sticky and slippery when wet.	Slight to moderate: fairly high seasonal water table; sticky and slippery when wet.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*—Continued

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Marsh (Ma)	Very severe: ponding; high water table.	Very severe: ponding; high water table.	Very severe: ponding; high water table.	Very severe: ponding; high water table.	Very severe: ponding; high water table.
Mayer loam (My)	Severe: poor drainage; high water table; sticky when wet.	Severe: poor drainage; high water table; sticky when wet.	Severe: poor drainage; high water table.	Severe: poor drainage; sticky when wet.	Severe: poor drainage; sticky when wet.
Oshawa silty clay loam (Os).	Very severe: frequent flooding; high water table; seasonal ponding; sticky and slippery when wet.	Very severe: frequent flooding; high water table; seasonal ponding; sticky and slippery when wet.	Very severe: frequent flooding; high water table; seasonal ponding.	Very severe: frequent flooding; high water table; seasonal ponding.	Very severe: frequent flooding; high water table; seasonal ponding.
Peat and muck, calcareous (Pc).	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.
Peat and muck, deep (Pd).	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.
Peat and muck, moderately shallow, over loam (Pm).	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.
Peat and muck, moderately shallow, over sand (Ps).	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; very poor drainage.
Rasset loamy sand, 0 to 6 percent slopes (RaB).	Moderate: loose sandy surface; blowing; difficult to establish vegetation.	Moderate: loose sandy surface; blowing; difficult to establish vegetation.	None to slight	Moderate: loose sandy surface.	Moderate: loose sandy surface; blowing; difficult to establish vegetation.
Rasset loamy sand, 6 to 12 percent slopes (RaC).	Severe: slope; loose sandy surface; difficult to establish vegetation.	Moderate: slope; loose sandy surface; difficult to establish vegetation.	Moderate: slope	Moderate: loose sandy surface.	Moderate: slope; loose sandy surface; difficult to establish vegetation.
Rasset loamy sand, 12 to 18 percent slopes (RaD).	Severe: slope; loose sandy surface; difficult to establish vegetation.	Severe: slope; loose sandy surface; difficult to establish vegetation.	Severe: slope	Moderate: slope; loose sandy surface.	Severe: slope; loose sandy surface; difficult to establish vegetation.
Salida loamy sand, 18 to 40 percent slopes (SaF).	Very severe: slope; difficult to establish vegetation.	Very severe: slope; difficult to establish vegetation.	Severe to very severe: slope.	Severe to very severe: slope.	Severe to very severe: slope; difficult to establish vegetation.
Sandy colluvial land (Sc).	Severe: gentle to moderate slopes; loose sandy surface; possible sidehill seepage; difficult to establish vegetation.	Moderate: gentle to moderate slopes; loose sandy surface; difficult to establish vegetation.	Moderate: possible sidehill seepage.	Slight to moderate: loose sandy surface.	Moderate to severe: gentle to moderate slopes; possible sidehill seepage; loose sandy surface; difficult to establish vegetation.

TABLE 6.—*Degree and kind of limitation for specified recreational uses*—Continued

Soil	Play areas for intensive use	Picnic areas for intensive use	Buildings in recreational areas	Paths and trails	Camp areas for intensive use
Sandy lake beaches (Sk).	Very severe: high water table; loose sandy surface; overflow; difficult to establish vegetation.	Very severe: high water table; loose sandy surface; overflow; difficult to establish vegetation.	Very severe: high water table; overflow.	Severe: loose sandy surface; overflow.	Very severe: loose sandy surface; overflow; difficult to establish vegetation.
Storden-Lester loams, 6 to 12 percent slopes, eroded (SlC2).	Severe: slope	Moderate: slope	Moderate: slope	Moderate: sticky when wet.	Moderate: slope; sticky when wet.
Storden-Lester loams, 12 to 18 percent slopes, eroded (SlD2).	Severe: slope	Severe: slope	Severe: slope	Moderate: slope; sticky when wet.	Severe: slope; sticky when wet.
Talcot silty clay loam (Ta).	Very severe: seasonal ponding; high water table; sticky and slippery when wet.	Very severe: seasonal ponding; high water table; sticky and slippery when wet.	Very severe: seasonal ponding; high water table; very poor drainage.	Very severe: seasonal ponding; high water table; sticky and slippery when wet.	Very severe: seasonal ponding; high water table; very poor drainage; sticky and slippery when wet.
Terril loam, 0 to 6 percent slopes (TeB).	Severe: fairly high seasonal water table; moderate drainage.	Slight to moderate: fairly high seasonal water table; moderate drainage.	Slight to moderate: fairly high seasonal water table; moderate drainage.	None to slight	Slight to moderate: moderate drainage; fairly high seasonal water table.
Terril loam, 7 to 11 percent slopes (TeC).	Severe: fairly high seasonal water table; moderate drainage.	Slight to moderate: fairly high seasonal water table; moderate drainage.	Slight to moderate: fairly high seasonal water table; moderate drainage.	None to slight	Slight to moderate: moderate drainage; fairly high seasonal water table.
Terril loam, occasionally flooded (To).	Severe: occasional flooding: fairly high seasonal water table.	Severe: occasional flooding; fairly high seasonal water table.	Severe: occasional flooding; fairly high seasonal water table.	Moderate: occasional flooding.	Severe: occasional flooding.
Wadena loam, 0 to 2 percent slopes (WaA).	None to slight	None to slight	None to slight	None to slight	None to slight.
Wadena loam, 2 to 6 percent slopes (WaB).	Moderate: slope	None to slight	None to slight	None to slight	None to slight.
Wadena loam, 6 to 12 percent slopes, eroded (WaC2).	Severe: slope	Moderate: slope	Moderate: slope	None to slight	Moderate: slope.

The degree and kind of limitations of the soils for specified recreational uses are given in table 6. The degrees of limitation are expressed as *none to slight*, *moderate*, *severe*, and *very severe*. The limitation is *none to slight* if the soil is suitable for the specified use. The limitation is *moderate* if the soil can be used but needs to be well managed. The limitation is *severe* if use is questionable. It is *very severe* if use is extremely limited or unsound. The interpretations shown in table 6 are based on soil characteristics and do not include other factors to be considered in selecting an area for a specified recreational use.

Play areas for intensive use.—Areas used for playgrounds and for organized games, including baseball, football, and badminton, are subject to heavy foot traffic. The soils selected should be nearly level, have a firm surface, and have good drainage. They should not be subject to flooding.

Picnic areas for intensive use.—The limitations of the soils for use as picnic areas are based on soil characteristics. Other factors, such as the number of trees or lakes in the area, that affect the desirability of the site were not considered. The soils selected should be nearly level to gently sloping, have a firm surface, and have good drainage. They should not be subject to blowing or flooding.

Buildings in recreational areas.—Table 6 gives the limitations of the soils as sites for seasonal and year-round cottages, washrooms, bathhouses, picnic shelters, and other service buildings in recreational areas. The most desirable soils are nearly level to gently sloping, have good drainage, and are not subject to flooding. The interpretations in

table 6 give only general information. A detailed onsite investigation is needed at the specified location.

Paths and trails.—Table 6 gives the limitations of the soils for use as bridle paths and trails for hiking, and for other nonintensive uses that involve random movement of people. The characteristics considered are the slope, the soil texture, the degree of wetness, and the hazard of flooding. Soils that have no limitation or only slight limitation generally are nearly level to rolling, have a firm surface, have good drainage, and are not subject to flooding. Some soils that have severe limitations would be desirable because they are in a scenic location, but these soils would require considerable preparation and maintenance.

Camp areas for intensive use.—The areas used frequently as campsites, including tent and trailer sites, should require little site preparation. They should be suitable for unsurfaced parking for cars and camp trailers and for heavy traffic by humans, horses, or vehicles. The most suitable sites are nearly level to gently sloping, have a firm surface in all kinds of weather, have good drainage, and are not subject to flooding or blowing.

Formation and Classification of the Soils

This section describes the factors that influence soil formation and shows the classification of the soils of Carver County by series and higher categories.

Factors of Soil Formation

The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the soil material. These five factors of soil formation are interdependent; each modifies the effects of the others.

Climate and vegetation are the active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. Usually a long time is required for the development of distinct horizons.

Man also has influenced the development of soils. He has removed the natural vegetation and has used methods of farming that have accelerated erosion and changed the relief or the effects of relief. Man has also modified the natural differences among soils by adding material that has improved the fertility of some soils, and by removing crops without replacing plant nutrients, which has lowered the fertility of others.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

The five factors of soil formation as they occur in Carver County are described in the pages that follow.

Parent material

Carver County is in the Western Young Drift section of the Central Lowland province (*5*). This section is characterized by young glaciated plains, moraines, lakes, and lacustrine beds. The most extensive sources of parent material in the county are glacial till and glacial outwash. Less extensive sources are alluvium, colluvium, and organic material.

The differences among these parent materials account for many of the differences among the soils. Normally, parent material is a mixture of clays and unweathered minerals and rock fragments that vary considerably in compaction characteristics. This mixture develops into soils, the characteristics of which depend almost entirely on the factors of vegetation and biological activity, relief, climate, and time (*8*). After a long period, the influence of the parent material is obliterated by the effects of the other soil-forming factors. In many soils, even at a depth of 2 or 3 feet, there is no evidence of the kind of parent material from which the soils were derived.

Glacial Till

Three continental glaciers, the Nebraskan, The Kansan, and the Wisconsin, covered all of Carver County. The material deposited by the Nebraskan and Kansan ice sheets, both of which occurred about 1 to 2 million years ago, is deeply buried under that deposited by the Wisconsin, which terminated about 10,000 years ago.

The Wisconsin glacier deposited four kinds of till in the county. The first extensive lobe, the Iowan, covered all of the county. The gray drift deposited was subsequently mantled by drift from the Cary Keewatin lobe. The till in this drift is grayish or yellowish brown, silty or clayey, and highly calcareous. Following the Cary Keewatin, the Cary Patrician lobe passed over the northeastern part of the county and deposited red, sandy drift that contained less clay than that deposited by the Keewatin lobe and few, if any, limestone pebbles. The uppermost till sheet, by far the most extensive source of parent material in the county, was deposited during the Mankato substage, the last invasion of the glaciers into Carver County. The till deposited is yellowish or light olive brown slightly mottled with pale yellow or gray. It ranges from loam to clay loam in texture, is calcareous, and contains many limestone pebbles. The content of calcium carbonate is high, and the material effervesces strongly with hydrochloric acid. In most of the upland soils formed in this material, the depth of leaching is less than 4 feet. This material was derived mostly from limestone and calcareous shale, but it contains enough granite and sandstone to provide an abundance of minerals and a favorable range in soil texture. The Lester, Hayden, and LeSueur are examples of soils that formed in glacial till.

Glacial Outwash

Glacial outwash consists of material originally carried by glaciers and then swept out, sorted, and deposited beyond the glacial front by streams and melt water. The

deposits of glacial outwash in Carver County are of Mankato origin. The most extensive areas formed from these deposits are the outwash plains and terraces along the Minnesota River and the South Fork Crow River. These areas for the most part are nearly level to undulating, but some on the terraces above the Minnesota River are rolling to hilly and appear to be pitted. Presumably, the pits were unfilled, iceblocked depressions of glacial origin.

Much of the outwash near moraines is poorly sorted, but the rest is stratified and well sorted. The terraces above the Minnesota River are made up of stratified sand, gravel, and clay. Near the towns of East Union, Chaska, and Carver, there are extensive deposits of clay. Such deposits indicate that water was ponded in the Minnesota River valley near the close of the glacial period.

Many different kinds of soils formed in glacial outwash. The upper part of these soils ranges from fine sand to silty clay; the lower part consists of sand, gravel, and clay; and the depth to free lime carbonates ranges from 2 to more than 6 feet. The Estherville, Wadena, and Kasota are examples of soils that formed in glacial outwash.

Organic Matter

Organic soils, which form mainly in the remains of aquatic reeds, grasses, and sedges, are extensive in the numerous depressions, drainageways, and old lake bottoms throughout the county. Because of continual wetness and a high water table in these areas, the organic material forms more quickly than it decomposes.

If the organic remains are intact and fresh enough to permit identification of plant forms, the material is called peat. If recognition of plant forms is impossible, the material is called muck.

Alluvium

Alluvium consists of sediments that have been moved and redeposited by streams. It occurs on flood plains along streams in the county, or on old stream terraces and flood plains that are now at a much higher elevation than the present streams.

The largest areas of alluvium are on broad flood plains along the Minnesota River, but there are also fairly large areas on the flood plains of other rivers in the county. The frequency of flooding varies. The material varies widely in texture, color, reaction, and drainage and generally is stratified. The deposits are too recent for a soil profile to have formed, but in places the material is mottled. Comfrey soils are examples of soils that formed in alluvium.

Colluvium

Colluvium, which occurs at the base of slopes, is soil material that has been moved into place through creep and local wash. Within the glacial uplands of the county, this material overlies glacial till. On the outwash plains the colluvium is in channels and slight depressions and overlies glacial outwash sand and gravel.

The soils that formed in colluvium in this county range from loamy sands to silty clay loams. They are slightly alkaline to medium acid and are well drained to poorly drained. Terril soils, for example, formed in colluvium.

Climate

Climate is a major factor in determining what kinds of soils develop from different kinds of parent material. It determines the vegetation and influences the rate and intensity of hydrolysis, hydration, carbonation, oxidation, and other important chemical reactions in the soil. The effects of climate and vegetation, in turn, vary according to the topography and to the length of time the parent material has been in place.

The climate of Carver County is of the subhumid, continental type. It is described in the section "Additional Facts About the County." The temperature varies widely from summer to winter. Generally, the soils are frozen to a depth of 3 to 5 feet for 4 or 5 months of the year. The depth to which frost penetrates depends for the most part on the amount of snow received late in fall or early in winter. The snow prevents water erosion and slows denitrification. Except for some alternate freezing and thawing, the soil-forming forces are largely dormant in winter.

The climate is essentially uniform throughout the county. The slight variations that affect soil formation result from differences in vegetation, soil material, and relief.

Prairie soils are exposed to greater variation in temperature than soils in forested areas. On the gently rolling or undulating uplands, the effect of climate is shown in the depth of weathering. Weathering is more rapid in soils that remain moist than in those that dry out or in those that remain saturated most of the year. Fine-textured soils warm up more slowly than coarse-textured soils because they contain more moisture. Dark-colored soils absorb more heat from the sunlight than light-colored soils. Soils on south- and west-facing slopes receive more sunlight than those on north- and east-facing slopes and therefore tend to be drier and warmer. The interaction of all these factors affects the development of soils.

Vegetation

Most of the county was covered with a thick growth of broadleaf hardwoods at the time of settlement. The trees were chiefly oak, elm, basswood, ash, and maple. There were very few pines or other coniferous trees. The few areas of prairie were covered with tall grass, thickets of aspen, and scattered oaks. The wet soils were covered with marsh grasses, reeds, and sedges. The original vegetation of the county is shown in figure 22, in the section "Use of Soils for Woodland."

Soils of the same age that have similar relief, drainage, and parent material have a thicker, darker colored surface soil if the native vegetation has been grass than if it has been forest. For the most part, the prairie soils in this county, Wadena soils, for example, are on the outwash plains and terraces.

The surface soil is lighter colored in forested areas than in grassy areas. Also, the downward movement of clay, organic matter, and plant nutrients is more rapid, and the subsoil generally is less permeable. The largest area of forest in the county is in the eastern part. The Hayden soils developed in this area.

Many of the soils in Carver County appear to have developed in an ecological tension zone in which the boundary between prairie and forest vegetation shifted back and forth, possibly as a result of fire or changing climate. The surface layer of these soils is dark colored, but it is thinner than is usual in soils that developed under grass. The subsurface layer is a grayish, incipient to distinct podzolized horizon, like that characteristic of soils

in forested areas. In some undisturbed sandy soils this layer is not apparent, and in others it consists only of bleached sand grains. The subsoil shows a marked increase in clay and organic-matter content. These intergraded soils, of which Lester soils are typical, are widely distributed in Carver County, particularly throughout the western and southwestern parts.

Relief

Relief is an important factor in the formation of soils because of its effect on drainage, aeration, and erosion. The degree of development of soils in a given time, from similar parent material and under similar vegetation, depends largely on the amount of water that passes through the soil.

The relief of Carver County ranges from nearly level plains to hilly moraines and depressions. Soil development is most rapid on well-drained, gentle slopes. It is very slow on steep slopes because runoff is rapid, infiltration is slow, and erosion removes the surface soil almost as fast as it forms. Little or no development takes place in depressions or level areas where there is a permanent high water table.

The direction of the slope is an important factor also. The rays of the sun are much less effective in heating the soil and evaporating moisture on north-facing slopes than on south-facing slopes. Consequently, on north-facing slopes the soils contain more moisture and are darker colored, and the vegetation is denser.

Figure 23 shows the topography, the drainage classes, and the vegetation of the major soils in the county.

Time

The soils in Carver County vary in stages of maturity, depending on the length of time the soil-forming factors have been active.

The youngest are the soils that developed in alluvium and are altered by every flood, such as the Comfrey soils; the organic soils, such as Peat and muck; and the soils that developed in colluvium and are continually altered by new deposits, such as Terril soils.

The very steep soils in this county are intermediate in maturity. They are shallow and generally have weak or distinct, but not prominent, horizons. On very steep slopes, soil is removed almost as fast as it forms.

Most of the undulating to rolling upland soils, such as Lester and Hayden soils, have well-developed horizons. The nearly level Estherville and Wadena soils also have well-developed horizons because they lose little surface soil and have good internal drainage. The very poorly drained Glencoe soils, which are in depressions, show little horizonation because wetness inhibits the soil-forming processes.

Classification of the Soils

Two systems of classifying soils are now in general use in the United States. One of these is the 1938 system (*4*), with later revisions. The other, the current system (*9*), has been used by the National Cooperative Soil Survey since 1965. Both are used in this publication.

The current system has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria for classification are the observable or measurable properties. The properties are so chosen that soils of similar mode of origin are grouped together. Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available. Readers interested in the development of this system should refer to the latest available literature (*7*).

The 1938 system, with later revisions, also has six categories, the most inclusive of which is the order. The next two categories, the suborder and the family, have never been fully developed and consequently have been little used. Attention has been centered largely on the great soil group, the soil series, and the soil type.

New soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept at national, State, and regional levels of responsibility for soil classification results in a judgment that the new series should be established. Most of the soil series

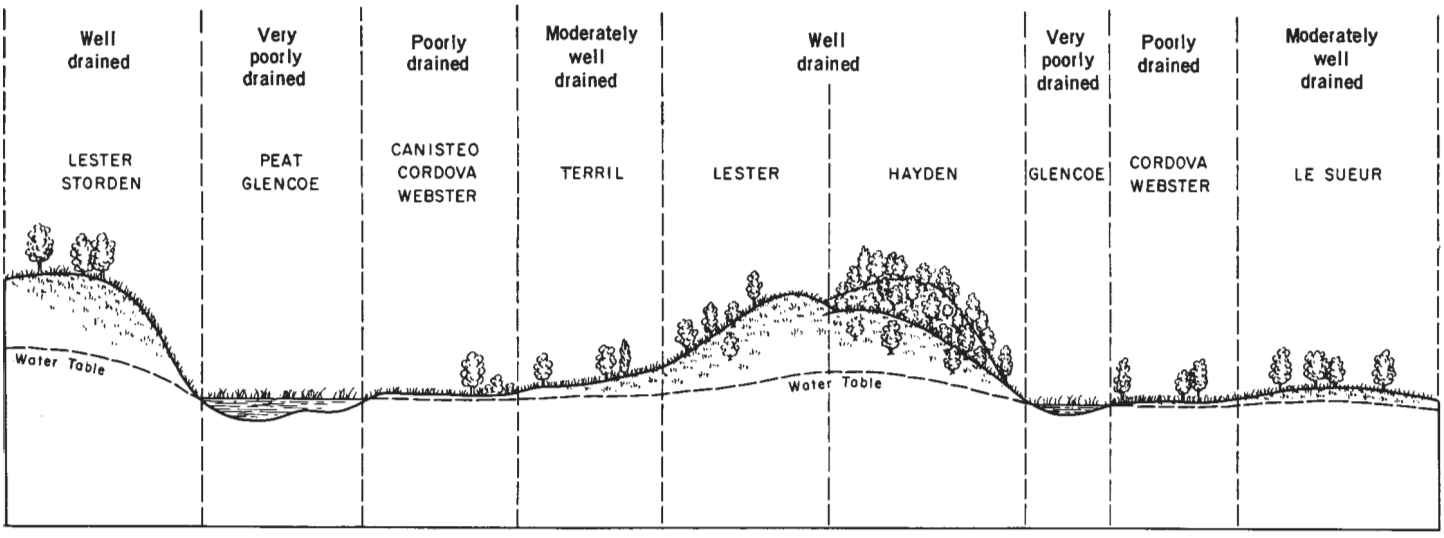

Figure 23.—**Topography, drainage, and vegetation of major soils.**

described in this publication were established before this survey was made. Two of the soil series represented in the county, however, are tentative at present. These are the Chaska and Mayer series.

Table 7 shows the classification of each soil series of Carver County by family, subgroup, and order of the current classification system, and by great soil group of the 1938 system.

TABLE 7.—*Soil series and variants classified according to the current system of classification and the 1938 system, with its later revisions*

Soil series and variants	Current classification			1938 classification
	Family	Subgroup	Order	Great soil group
Biscay	Fine-loamy over sandy-skeletal, mixed, noncalcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Biscay, sandy subsoil variant.	Fine-loamy over sandy, mixed, noncalcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Burnsville	Coarse-loamy, mixed, mesic	Typic Hapludalfs	Alfisols	Gray-Brown Podzolic soils.
Canisteo	Fine-loamy, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Chaska	Fine-loamy, mixed, calcareous, mesic.	Cumulic Haplaquolls	Mollisols	Alluvial soils.
Comfrey	Fine-loamy, mixed, noncalcareous, mesic.	Cumulic Haplaquolls	Mollisols	Alluvial soils.
Cordova	Fine, mixed, noncalcareous, mesic	Typic Argiaquolls	Mollisols	Humic Gley soils.
Dakota	Fine-loamy over sandy or sandy-skeletal, mixed, mesic.	Typic Argiudolls	Mollisols	Brunizems.
Estherville	Coarse-loamy over sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Fairhaven	Fine-loamy over sandy or sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Fairhaven, deep variant.	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols	Brunizems.
Glencoe	Fine-loamy, mixed, noncalcareous, mesic.	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Hayden	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols	Gray-Brown Podzolic soils.
Hubbard	Sandy, mixed, frigid	Entic Haploborolls	Mollisols	Brunizems.
Kasota	Fine-loamy over sandy, mixed, mesic	Typic Argiudolls	Mollisols	Brunizems.
Lester	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols	Brunizems intergrading to Gray-Brown Podzolic soils.
LeSueur	Fine-loamy, mixed, mesic	Aquic Argiudolls	Mollisols	Brunizems intergrading to Gray-Brown Podzolic soils.
Mayer	Fine-loamy over sandy-skeletal, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Oshawa	Fine-loamy, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols	Alluvial soils.
Rasset	Coarse-loamy, mixed, mesic	Psammentic Argiudolls	Mollisols	Brunizems intergrading to Gray-Brown Podzolic soils.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols	Regosols intergrading to Brunizems.
Storden	Fine-loamy, mixed, mesic	Entic Hapludolls	Mollisols	Regosols.
Talcot	Fine-loamy over sandy-skeletal, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems.
Wadena	Fine-loamy over sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Webster	Fine-loamy, mixed, noncalcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.

Additional Facts About the County

Carver County was created in 1855. It was named for Jonathan Carver, who explored a large part of Minnesota about the middle of the 18th century. Chaska was the first village in the county.

Dairying is the most important industry. The county is in the Minneapolis-St. Paul milkshed. The Twin City milk receiving station is in Watertown; creameries are located in Chaska, Waconia, Norwood, and Bongards; and there is a cheese factory in Bongards.

Other industries include the raising and marketing of livestock, the operation of feed mills, the manufacture of wood products in Carver and Victoria, and the manufacture of metal products in Chaska and Waconia. There is a brick factory in Chaska and a toy factory and a concrete-

mixing plant in Chanhassen. The county also has a pickle factory and a large refining plant for sugar beets in Chaska, and a cannery for sweet corn in Watertown.

Climate[4]

Carver County has a continental-type climate. Summers are warm and pleasant. Winters are cold. Both seasons are characterized by frequent day-to-day changes as weather systems move across the county from west to east.

[4] By DONALD A. HAINES, State climatologist, U.S. Weather Bureau.

The mean temperature for December, January, and February is 17° F. The temperature drops to or below zero on an average of 38 days each winter. The mean temperature from June through August is 71.3°, but on the average there are 16 days in summer when the temperature reaches 90° or above. Temperature data are given in tables 8, 9, and 10. Table 8 also gives precipitation data.

Snowfall is moderate. The first measurable fall of the season generally occurs in November, and the last, late in March or early in April. Severe blizzards are infrequent. The paths of the winter storms that develop in the southwestern part of the State are generally south of this county. Excessive drifting of snow rarely occurs, because

TABLE 8.—*Temperature and precipitation data*

[All data from records kept at Weather Bureau Station, Chaska, Minn., 1931–60. Elevation, 725 feet]

Month	Temperature					Precipitation				
				Two years in 10 will have at least 4 days with—			One year in 10 will have—			
	Average daily maximum	Average daily minimum	Monthly mean	Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—	Average total	Less than—	More than—	Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	°F.	°F.	°F.	°F.	°F.	In.	In.	In.	No.	In.
January	24	4	14	42	−22	0.5	0.1	1.0	23	5
February	28	6	17	44	−17	.7	.2	1.5	24	6
March	39	20	29	61	−4	1.4	.4	2.6	14	5
April	58	34	46	78	22	1.9	.8	3.4	1	3
May	71	46	58	88	32	4.0	1.1	7.3	[1]	1
June	81	56	69	93	44	4.9	2.0	8.0	0	
July	87	61	74	100	49	3.9	1.8	7.2	0	
August	84	58	71	94	46	3.6	1.6	6.5	0	
September	75	49	62	92	35	2.6	.6	5.3	0	
October	63	38	50	80	24	1.6	.4	2.9	[1]	1
November	42	23	32	62	5	1.3	.4	2.6	3	3
December	28	10	20	44	−12	.7	.1	1.2	17	4
Year	57	34	45	[2] 99	[3] −26	27.1	21.3	34.2	82	4

[1] Less than 0.5 day.
[2] Average annual highest temperature.
[3] Average annual lowest temperature.

TABLE 9.—*Probability of freezing temperatures in spring and fall*

[All data from records kept at Weather Bureau Station, Maple Plain, Hennepin County, Minn. Elevation, 1,025 feet]

Probability	Dates for given probability and temperature				
	16° F.	20° F.	24° F.	28° F.	32° F.
Spring:					
1 year in 10 later than	April 10	April 19	April 28	May 9	May 22
2 years in 10 later than	April 5	April 14	April 24	May 5	May 17
5 years in 10 later than	March 26	April 4	April 16	April 25	May 7
Fall:					
1 year in 10 earlier than	October 27	October 18	October 9	September 25	September 9
2 years in 10 earlier than	November 1	October 23	October 14	October 2	September 26
5 years in 10 earlier than	November 10	November 2	October 26	October 14	October 5

of the absence of high winds. Slushy conditions caused by alternate thawing and freezing occur infrequently; afternoon temperatures usually remain below freezing in winter.

TABLE 10.—*Probability of length of growing season*

[All data from records kept at Maple Plain, Hennepin County, Minn. Elevation, 1,025 feet]

Probability	Number of consecutive days free of temperatures as low as, or lower than—				
	16° F.	20° F.	24° F.	28° F.	32° F.
1 year in 10	250	234	213	195	170
3 years in 10	237	221	201	181	158
5 years in 10	229	213	192	171	150
7 years in 10	221	204	184	162	143

The probability of the last freezing temperature in spring and the first in fall (*2*, *3*) is given in table 9. The probability of the number of days in the growing season (*2*, *3*) is given in table 10.

About 70 percent of the annual precipitation falls during the growing season, from May through September. The supply of moisture is ample for farm and garden crops. Thunderstorms bring most of the rain during the growing season.

Damaging storms, such as tornadoes and ice storms (glaze), are infrequent. Only seven of these violent storms occurred during the years 1916 through 1965. Heavy rains, wind, hail, and thunderstorm line squalls have caused localized damage each year.

Long-term records of humidity, the amount of cloudiness, and the wind direction are not available for Carver County, but records kept at the Minneapolis Weather Bureau, which is 18 miles northeast of the county, show that noontime humidity in summer averages 57 percent, and in winter about 67 percent. During a typical year about 103 days are clear, 101 are partly cloudy, and 161 are cloudy. The prevailing wind direction is northerly from December through April and southerly the rest of the year.

Physiography

A sheet of glacial drift 200 to 300 feet thick covers all of Carver County. There are small areas of modified drift or outwash near the rivers and streams. The northeastern and central parts of the county are strongly rolling to hilly, and the western and southern parts are undulating to rolling.

The Minnesota River valley is bordered by bluffs that rise 200 to 250 feet above the level of the river. The upland near the valley is dissected by many short tributary valleys. The flood plains are as much as 3 miles wide.

The highest elevations, about 1,000 feet, are in the southwestern townships and in Chanhassen and Laketown Townships in the northeastern part of the county. The lowest elevations are on the flood plain of the Minnesota River.

Rivers and Lakes

The South Fork Crow River enters the county on the west, near New Germany, bends sharply to the south, and then flows in a northeasterly course toward Watertown. It drains an area of approximately 110 square miles in the western and northwestern parts of the county. Its most important tributaries in this county are Buffalo Creek and the outlets of Tiger and Swan Lakes.

Minnetonka Lake, which extends into the northeastern part of the county, drains an area of about 15 square miles in the northern part of Laketown and Chanhassen Townships.

The Minnesota River drains the rest of the county. Its main tributaries in the county are Bevens and Carver Creeks. Bevens Creek enters the county on the southwest and flows in an easterly course to its outlet southeast of East Union. Carver Creek, which originates in the numerous lakes in Waconia Township, flows in a southeasterly course to its outlet near Carver. South of these tributaries are three smaller creeks, each about 6 miles long, that join the Minnesota River at Chaska and a few miles east of Chaska.

Farming

In 1964, approximately 212,300 acres, or 93 percent of the total land area in the county, was in farms. Of the estimated 1,596 farms, 1,079 were dairy farms. More than 129,000 acres of the county was cropped, about 35,600 acres was wooded, and more than 5,000 acres was pastured.

Corn is the most important crop. Alfalfa is second in importance, and oats, third. Wheat, barley, and rye are minor crops.

The number of cattle and calves increased about 7 percent between 1959 and 1964. The number of milk cows decreased slightly during this period.

Farms in Carver County are increasing in size. In 1964, the average size of farms was 133 acres, as compared with 127 acres in 1959.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Clay. As a soil separate, mineral soil particles that are less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. (See also Texture, soil.)

Concretions. Grains, pellets, or nodules that consist of concentrations of compounds or of soil grains cemented together. They are of various sizes, shapes, and colors. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artifically.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active, and it is therefore marked by the accumulation of humus. The horizon may have lost one or more of these: soluble salts, clay, or sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused by (1) accumulation of clay, sesquioxides, humus, or some combination of these; or (2) prismatic or blocky structure; or (3) redder or stronger colors; or (4) some combination of these characteristics. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. This layer, commonly called the soil parent material, is presumed to be like that from which the overlying horizons were formed in most soils. If the underlying material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Humus. The well-decomposed, more or less stable part of the organic matter in mineral soils.

Moisture-storage capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greater dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Natural drainage. The conditions that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low moisture-storage capacity.

Somewhat excessively drained soils are also rapidly permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a moderately slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and are mottled in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods; podzolic soils commonly are mottled below a depth of 6 to 16 inches in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods. They are dark gray or black and are generally mottled within a depth of 18 inches. Mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Permeability. The ability of the soil to transmit air or water. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity. (See also Reaction, soil.)

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values or words as follows:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Sand. As a soil separate, individual rock or mineral fragments 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay. (See also Texture, soil.)

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay. (See also Texture, soil.)

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular),

and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by adding the words "coarse," "fine," or "very fine" to the name of the textural class.

Tilth, soil. The condition of the soil, especially of the soil structure, in relation to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil (engineering). Presumably a fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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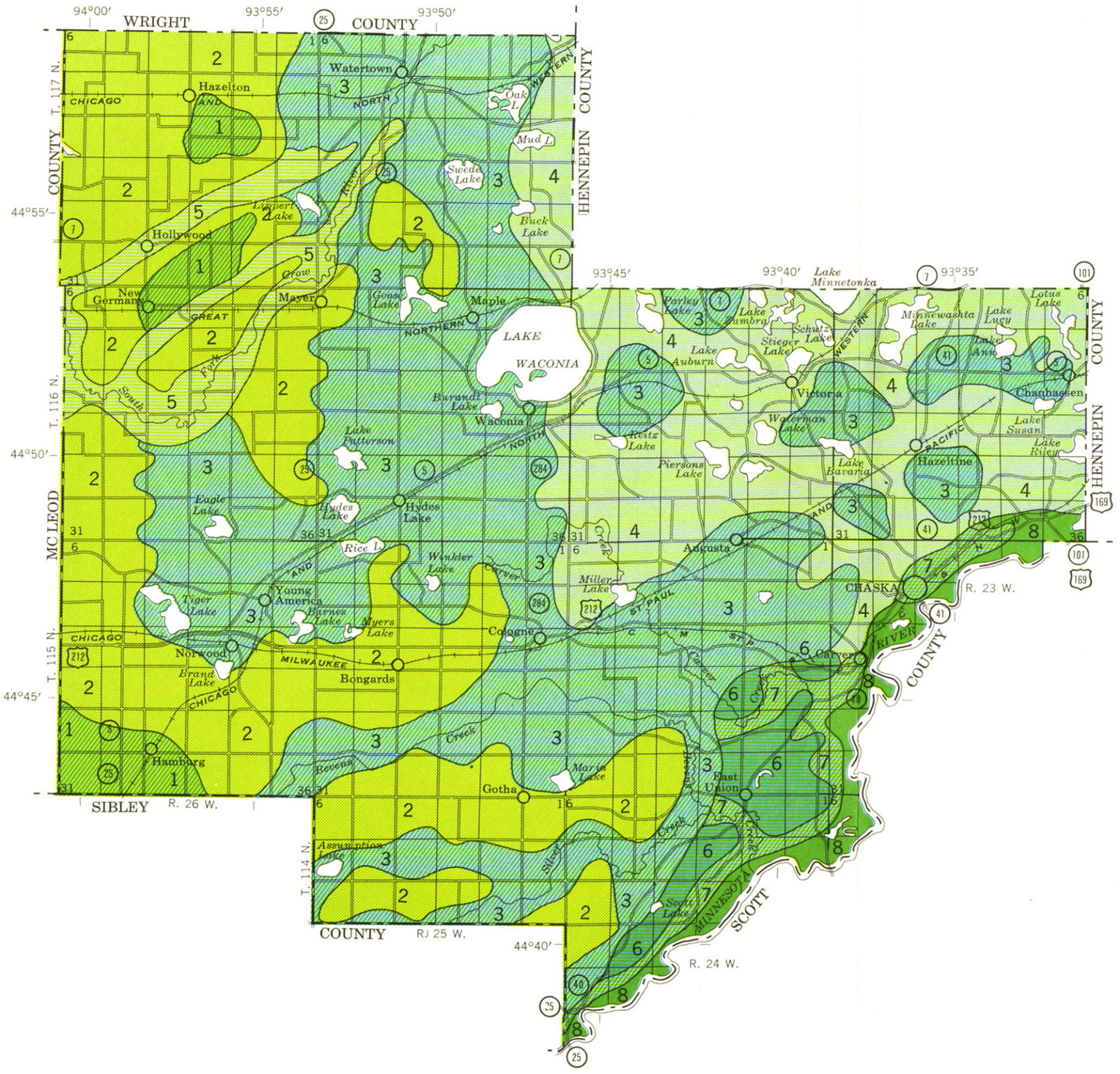
GENERAL SOIL MAP

CARVER COUNTY, MINNESOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MINNESOTA AGRICULTURAL EXPERIMENT STATION



SOIL ASSOCIATIONS

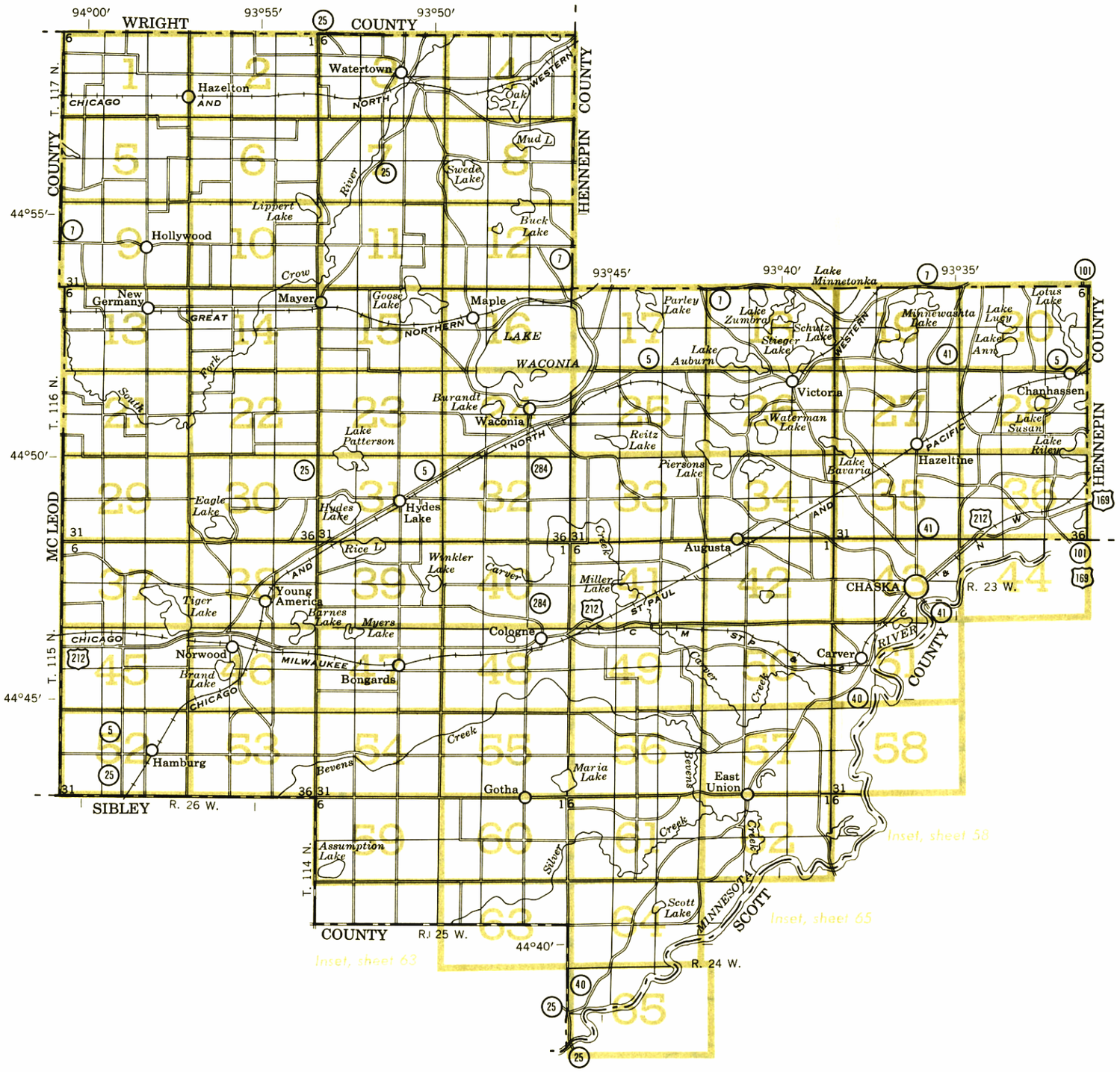
1. Cordova-Webster-LeSueur association: Nearly level to gently sloping, deep, moderately fine textured soils mainly on broad flats in the uplands
2. Lester-LeSueur-Peat associaton: Gently rolling, deep, medium-textured to moderately fine textured soils in the uplands
3. Lester-Hayden-Peat association: Rolling, deep, medium-textured to moderately fine textured soils in the uplands
4. Hayden-Lester-Peat association: Strongly rolling to hilly, deep, medium-textured to moderately fine textured soils in the uplands
5. Mayer-Esthervillé-Talcot association: Nearly level to gently undulating, medium-textured soils moderately deep to shallow over sand and gravel; on outwash plains along the South Fork Crow River
6. Fairhaven-Kasota-Estherville association: Nearly level to strongly rolling, medium-textured soils moderately deep to shallow over sand and gravel; on outwash terraces above the Minnesota River
7. Salida-Hayden association: Very steep, coarse-textured to medium-textured soils on hills and bluffs
8. Alluvial land-Chaska-Oshawa association: Chiefly medium-textured to moderately fine textured soils on flood plains along the Minnesota River

SCALE IN MILES
1 0 1 2 3 4

June 1968

INDEX TO MAP SHEETS

CARVER COUNTY, MINNESOTA



N

SCALE IN MILES

1 0 1 2 3 4

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are for nearly level soils or land types, but some are for land types that have a considerable range in slope. A final number, 2 or 3, in the symbol, shows that the soil is eroded or severely eroded.

SYMBOL	NAME
Al	Alluvial land
Au	Alluvial land, frequently flooded
Bc	Biscay loam
Bd	Biscay loam, sandy subsoil variant
BhB	Burnsville–Hayden complex, 2 to 6 percent slopes
BhC	Burnsville–Hayden complex, 6 to 12 percent slopes
BuD	Burnsville–Hayden sandy loams, 12 to 18 percent slopes
BuE	Burnsville–Hayden sandy loams, 18 to 25 percent slopes
Ca	Canisteo silty clay loam
Cd	Canisteo silty clay loam, depressional
Ch	Chaska silty clay loam
Cm	Comfrey silty clay loam
Co	Comfrey silty clay loam, frequently flooded
Cs	Cordova silty clay loam
Cw	Cordova and Webster silty clay loams
DrA	Dakota and Rasset sandy loams, 0 to 2 percent slopes
DrB	Dakota and Rasset sandy loams, 2 to 6 percent slopes
EsA	Estherville sandy loam, 0 to 2 percent slopes
EsB	Estherville sandy loam, 2 to 6 percent slopes
EsB2	Estherville sandy loam, 2 to 6 percent slopes, eroded
EsC	Estherville sandy loam, 6 to 12 percent slopes
EsC2	Estherville sandy loam, 6 to 12 percent slopes, eroded
EsD	Estherville sandy loam, 12 to 18 percent slopes
EsE	Estherville sandy loam, 18 to 25 percent slopes
FaA	Fairhaven silt loam, sand substratum, 0 to 2 percent slopes
FaB	Fairhaven silt loam, sand substratum, 2 to 6 percent slopes
FaC2	Fairhaven silt loam, sand substratum, 6 to 12 percent slopes, eroded
FhA	Fairhaven silt loam, deep variant, 0 to 3 percent slopes
Ge	Glencoe silty clay loam
HaB	Hayden loam, 2 to 6 percent slopes
HaB2	Hayden loam, 2 to 6 percent slopes, eroded
HaC	Hayden loam, 6 to 12 percent slopes
HaC2	Hayden loam, 6 to 12 percent slopes, eroded
HaD	Hayden loam, 12 to 18 percent slopes
HaD2	Hayden loam, 12 to 18 percent slopes, eroded
HaE2	Hayden loam, 18 to 25 percent slopes, eroded
HaF	Hayden loam, 25 to 40 percent slopes
HcC3	Hayden clay loam, 6 to 12 percent slopes, severely eroded
HcD3	Hayden clay loam, 12 to 18 percent slopes, severely eroded
HcE3	Hayden clay loam, 18 to 25 percent slopes, severely eroded
HdA	Hubbard loamy sand, 0 to 2 percent slopes
HdB	Hubbard loamy sand, 2 to 6 percent slopes
HdC	Hubbard loamy sand, 6 to 12 percent slopes
HdD	Hubbard loamy sand, 12 to 18 percent slopes
HdF	Hubbard loamy sand, 18 to 35 percent slopes
HuA	Hubbard sandy loam, 0 to 2 percent slopes
HuB2	Hubbard sandy loam, 2 to 6 percent slopes, eroded
HuC2	Hubbard sandy loam, 6 to 12 percent slopes, eroded
HuD	Hubbard sandy loam, 12 to 18 percent slopes
KaA	Kasota loam, 0 to 2 percent slopes
KaB2	Kasota loam, 2 to 6 percent slopes, eroded
KsA	Kasota sandy loam, 0 to 2 percent slopes
KsB2	Kasota sandy loam, 2 to 6 percent slopes, eroded
LaB	Lester loam, 2 to 6 percent slopes
LaB2	Lester loam, 2 to 6 percent slopes, eroded
LaC	Lester loam, 6 to 12 percent slopes
LaC2	Lester loam, 6 to 12 percent slopes, eroded
LaD2	Lester loam, 12 to 18 percent slopes, eroded
LeB	Lester–Estherville complex, 2 to 6 percent slopes
LeC2	Lester–Estherville complex, 6 to 12 percent slopes, eroded
LsA	LeSueur clay loam, 0 to 2 percent slopes
LsB	LeSueur clay loam, 2 to 6 percent slopes
Ma	Marsh
My	Mayer loam
Os	Oshawa silty clay loam
Pc	Peat and muck, calcareous
Pd	Peat and muck, deep
Pm	Peat and muck, moderately shallow, over loam
Ps	Peat and muck, moderately shallow, over sand
RaB	Rasset loamy sand, 0 to 6 percent slopes
RaC	Rasset loamy sand, 6 to 12 percent slopes
RaD	Rasset loamy sand, 12 to 18 percent slopes
SaF	Salida loamy sand, 18 to 40 percent slopes
Sc	Sandy colluvial land
Sk	Sandy lake beaches
SlC2	Storden–Lester loams, 6 to 12 percent slopes, eroded
SlD2	Storden–Lester loams, 12 to 18 percent slopes, eroded
Ta	Talcot silty clay loam
TeB	Terril loam, 0 to 6 percent slopes
TeC	Terril loam, 7 to 11 percent slopes
To	Terril loam, occasionally flooded
WaA	Wadena loam, 0 to 2 percent slopes
WaB	Wadena loam, 2 to 6 percent slopes
WaC2	Wadena loam, 6 to 12 percent slopes, eroded

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Creamery

Mines and Quarries
- Mine dump
- Pits, gravel or other

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

BOUNDARIES

- National or state
- County
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches (CANAL)

Lakes and ponds
- Perennial (water, w)
- Intermittent

Wells, water (flowing)

Spring

Marsh or swamp

Seep spot

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions

	Large	Small
Crossable with tillage implements		
Not crossable with tillage implements		
Contains water most of the time		

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stony, very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Detrimental deposit

Soil map constructed 1967 by Cartographic Division, Soil Conservation Service, USDA, from 1963 aerial photographs. Controlled mosaic based on Minnesota plane coordinate system, south zone, Lambert conformal conic projection, 1927 North American datum.

GUIDE TO MAPPING UNITS

/For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs.

/See table 1, page 6, for approximate acreage and proportionate extent of the soils. See table 2, page 45, for predicted yields per acre of the principal crops. For facts about the engineering properties of the soils, turn to the section beginning on page 52, and for facts about recreational uses of the soils, see the section beginning on page 74/

Map symbol	Mapping unit	Described on page	Capability unit		Woodland group		Building-site group	
			Symbol	Page	Number	Page	Number	Page
Al	Alluvial land	9	IIw-2	36	8	51	11	74
Au	Alluvial land, frequently flooded	9	VIw-1	43	9	51	11	74
Bc	Biscay loam	9	IIw-1	35	8	51	9	74
Bd	Biscay loam, sandy subsoil variant	10	IIw-1	35	8	51	9	74
BhB	Burnsville-Hayden complex, 2 to 6 percent slopes	11	IIIe-5	38	4	50	4	72
BhC	Burnsville-Hayden complex, 6 to 12 percent slopes	11	IVe-3	41	4	50	5	73
BuD	Burnsville-Hayden sandy loams, 12 to 18 percent slopes	11	VIe-2	42	5	50	6	73
BuE	Burnsville-Hayden sandy loams, 18 to 25 percent slopes	11	VIIe-2	43	5	50	7	73
Ca	Canisteo silty clay loam	12	IIw-1	35	8	51	9	74
Cd	Canisteo silty clay loam, depressional	12	IIIw-1	39	9	51	10	74
Ch	Chaska silty clay loam	12	IIw-1	35	8	51	11	74
Cm	Comfrey silty clay loam	13	IIw-1	35	8	51	11	74
Co	Comfrey silty clay loam, frequently flooded	13	VIw-1	43	9	51	11	74
Cs	Cordova silty clay loam	14	IIw-1	35	8	51	9	74
Cw	Cordova and Webster silty clay loams	14	IIw-1	35	8	51	9	74
DrA	Dakota and Rasset sandy loams, 0 to 2 percent slopes	15	IIIs-1	39	4	50	1	53
DrB	Dakota and Rasset sandy loams, 2 to 6 percent slopes	15	IIIe-4	38	4	50	1	53
EsA	Estherville sandy loam, 0 to 2 percent slopes	16	IIIs-2	40	4	50	1	53
EsB	Estherville sandy loam, 2 to 6 percent slopes	16	IIIe-5	38	4	50	1	53
EsB2	Estherville sandy loam, 2 to 6 percent slopes, eroded	16	IIIe-5	38	4	50	1	53
EsC	Estherville sandy loam, 6 to 12 percent slopes	16	IVe-3	41	4	50	2	72
EsC2	Estherville sandy loam, 6 to 12 percent slopes, eroded	16	IVe-3	41	4	50	2	72
EsD	Estherville sandy loam, 12 to 18 percent slopes	16	VIe-2	42	5	50	3	72
EsE	Estherville sandy loam, 18 to 25 percent slopes	16	VIIe-2	43	5	50	3	72
FaA	Fairhaven silt loam, sand substratum, 0 to 2 percent slopes	18	IIs-1	36	1	48	1	53
FaB	Fairhaven silt loam, sand substratum, 2 to 6 percent slopes	18	IIe-4	35	1	48	1	53
FaC2	Fairhaven silt loam, sand substratum, 6 to 12 percent slopes, eroded	18	IIIe-3	37	2	50	2	72
FhA	Fairhaven silt loam, deep variant, 0 to 3 percent slopes	17	I-1	34	1	48	1	53
Ge	Glencoe silty clay loam	19	IIIw-1	39	9	51	10	74
HaB	Hayden loam, 2 to 6 percent slopes	20	IIe-3	34	1	48	4	72
HaB2	Hayden loam, 2 to 6 percent slopes, eroded	20	IIe-3	34	1	48	4	72
HaC	Hayden loam, 6 to 12 percent slopes	20	IIIe-2	36	2	50	5	73
HaC2	Hayden loam, 6 to 12 percent slopes, eroded	20	IIIe-2	36	2	50	5	73
HaD	Hayden loam, 12 to 18 percent slopes	20	IVe-1	40	2	50	6	73
HaD2	Hayden loam, 12 to 18 percent slopes, eroded	21	IVe-1	40	2	50	6	73
HaE2	Hayden loam, 18 to 25 percent slopes, eroded	21	VIe-1	42	3	50	7	73
HaF	Hayden loam, 25 to 40 percent slopes	21	VIIe-1	43	3	50	7	73
HcC3	Hayden clay loam, 6 to 12 percent slopes, severely eroded	20	IVe-1	40	2	50	5	73
HcD3	Hayden clay loam, 12 to 18 percent slopes, severely eroded	20	VIe-1	42	2	50	6	73
HcE3	Hayden clay loam, 18 to 25 percent slopes, severely eroded	20	VIIe-1	43	3	50	7	73
HdA	Hubbard loamy sand, 0 to 2 percent slopes	21	IVs-1	41	6	51	1	53
HdB	Hubbard loamy sand, 2 to 6 percent slopes	22	IVs-1	41	6	51	1	53
HdC	Hubbard loamy sand, 6 to 12 percent slopes	22	VIs-1	43	6	51	2	72
HdD	Hubbard loamy sand, 12 to 18 percent slopes	22	VIIs-1	44	7	51	3	72
HdF	Hubbard loamy sand, 18 to 35 percent slopes	22	VIIs-1	44	7	51	3	72
HuA	Hubbard sandy loam, 0 to 2 percent slopes	22	IIIs-1	39	4	50	1	53
HuB2	Hubbard sandy loam, 2 to 6 percent slopes, eroded	22	IIIe-4	38	4	50	1	53
HuC2	Hubbard sandy loam, 6 to 12 percent slopes, eroded	22	IVe-2	41	4	50	2	72
HuD	Hubbard sandy loam, 12 to 18 percent slopes	22	VIe-2	42	5	50	3	72
KaA	Kasota loam, 0 to 2 percent slopes	23	IIs-1	36	1	48	1	53
KaB2	Kasota loam, 2 to 6 percent slopes, eroded	23	IIe-4	35	1	48	1	53
KsA	Kasota sandy loam, 0 to 2 percent slopes	23	IIIs-1	39	4	50	1	53
KsB2	Kasota sandy loam, 2 to 6 percent slopes, eroded	23	IIIe-4	38	4	50	1	53
LaB	Lester loam, 2 to 6 percent slopes	24	IIe-2	34	1	48	4	72
LaB2	Lester loam, 2 to 6 percent slopes, eroded	24	IIe-2	34	1	48	4	72
LaC	Lester loam, 6 to 12 percent slopes	24	IIIe-1	36	2	50	5	73
LaC2	Lester loam, 6 to 12 percent slopes, eroded	24	IIIe-1	36	2	50	5	73
LaD2	Lester loam, 12 to 18 percent slopes, eroded	24	IVe-1	40	2	50	6	73
LeB	Lester-Estherville complex, 2 to 6 percent slopes	25	IIe-4	35	1	48	4	72
LeC2	Lester-Estherville complex, 6 to 12 percent slopes, eroded	25	IIIe-3	37	2	50	5	73
LsA	LeSueur clay loam, 0 to 2 percent slopes	26	I-1	34	1	48	8	73
LsB	LeSueur clay loam, 2 to 6 percent slopes	26	IIe-1	34	1	48	8	73
Ma	Marsh	26	VIIIw-1	44	9	51	10	74
My	Mayer loam	27	IIw-1	35	8	51	9	74
Os	Oshawa silty clay loam	27	VIw-1	43	9	51	11	74
Pc	Peat and muck, calcareous	27	IIIw-2	39	9	51	10	74
Pd	Peat and muck, deep	27	IIIw-2	39	9	51	10	74
Pm	Peat and muck, moderately shallow, over loam	27	IIIw-2	39	9	51	10	74
Ps	Peat and muck, moderately shallow, over sand	27	Vw-1	42	9	51	10	74
RaB	Rasset loamy sand, 0 to 6 percent slopes	28	IVs-1	41	6	51	1	53
RaC	Rasset loamy sand, 6 to 12 percent slopes	28	VIs-1	43	6	51	2	72
RaD	Rasset loamy sand, 12 to 18 percent slopes	28	VIIs-1	44	7	51	3	72
SaF	Salida loamy sand, 18 to 40 percent slopes	29	VIIs-1	44	7	51	3	72
Sc	Sandy colluvial land	29	IVs-1	41	6	51	8	73
Sk	Sandy lake beaches	29	VIIs-1	44	6	51	10	74
SlC2	Storden-Lester loams, 6 to 12 percent slopes, eroded	30	IIIe-1	36	2	50	5	73
SlD2	Storden-Lester loams, 12 to 18 percent slopes, eroded	30	IVe-1	40	2	50	6	73
Ta	Talcot silty clay loam	30	IIIw-1	39	9	51	10	74
TeB	Terril loam, 0 to 6 percent slopes	31	IIe-1	34	1	48	8	73
TeC	Terril loam, 7 to 11 percent slopes	31	IIIe-1	36	2	50	8	73
To	Terril loam, occasionally flooded	31	IIw-2	36	1	48	11	74
WaA	Wadena loam, 0 to 2 percent slopes	32	IIs-1	36	1	48	1	53
WaB	Wadena loam, 2 to 6 percent slopes	32	IIe-4	35	1	48	1	53
WaC2	Wadena loam, 6 to 12 percent slopes, eroded	32	IIIe-3	37	2	50	2	72

CARVER COUNTY, MINNESOTA — SHEET NUMBER 1

1

CARVER COUNTY, MINNESOTA — SHEET NUMBER 2

(2)

N

WRIGHT COUNTY

R. 26 W.

T. 117 N.

(Joins sheet 1)

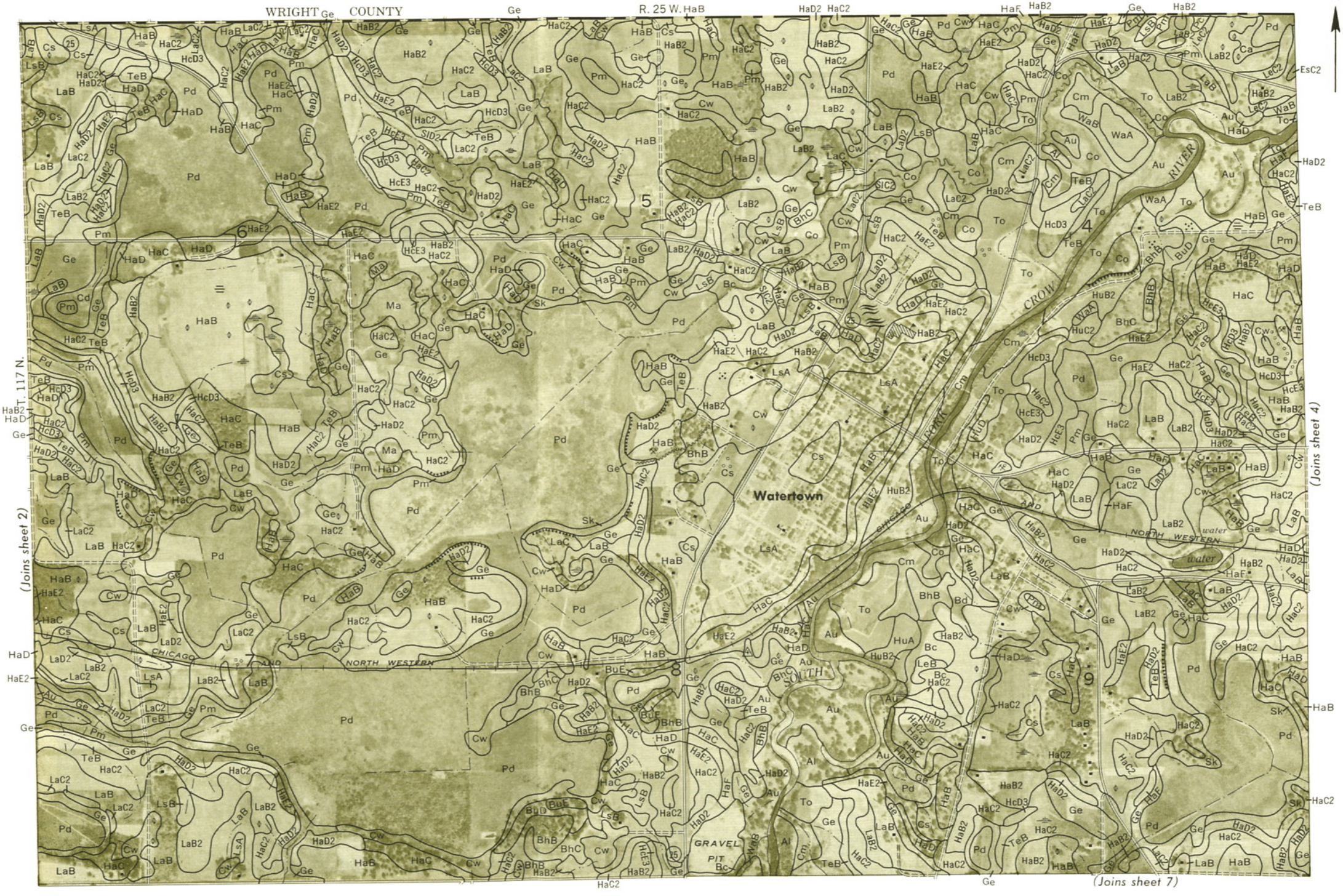
(Joins sheet 3)

(Joins sheet 6)

Neaton School

Hazelton

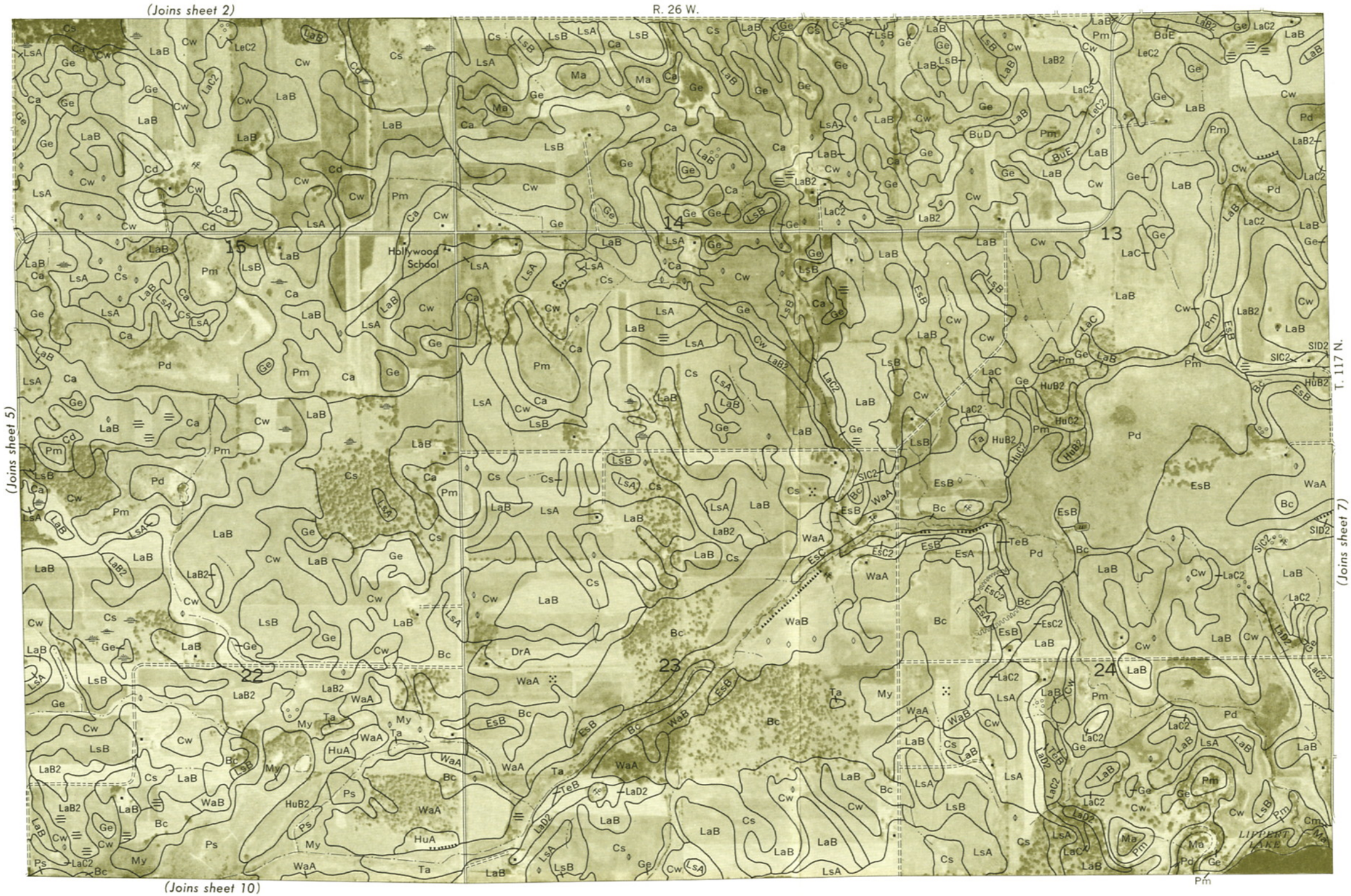
CHICAGO AND NORTH WESTERN


WRIGHT COUNTY
R. 25 W.
T. 117 N.
N
Watertown
CROW RIVER
CHICAGO AND NORTH WESTERN
SOUTH
GRAVEL PIT
water
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 7)

N
R. 25 W.
WRIGHT COUNTY
HENNEPIN COUNTY
T. 117 N.
RICE LAKE
OAK LAKE
Oak Lake School
water
CHICAGO AND NORTH WESTERN
(Joins sheet 3)
(Joins sheet 8)

N
R. 26 W.
(Joins sheet 1)
(Joins sheet 6)
(Joins sheet 9)
T. 117 N.
MC LEOD COUNTY
CAMPBELL LAKE
16
17
18
19
20
21

6


N
(Joins sheet 2)
R. 26 W.
T. 117 N.
(Joins sheet 5)
(Joins sheet 7)
(Joins sheet 10)
Hollywood School
LIPPERT LAKE
13
14
15
22
23
24

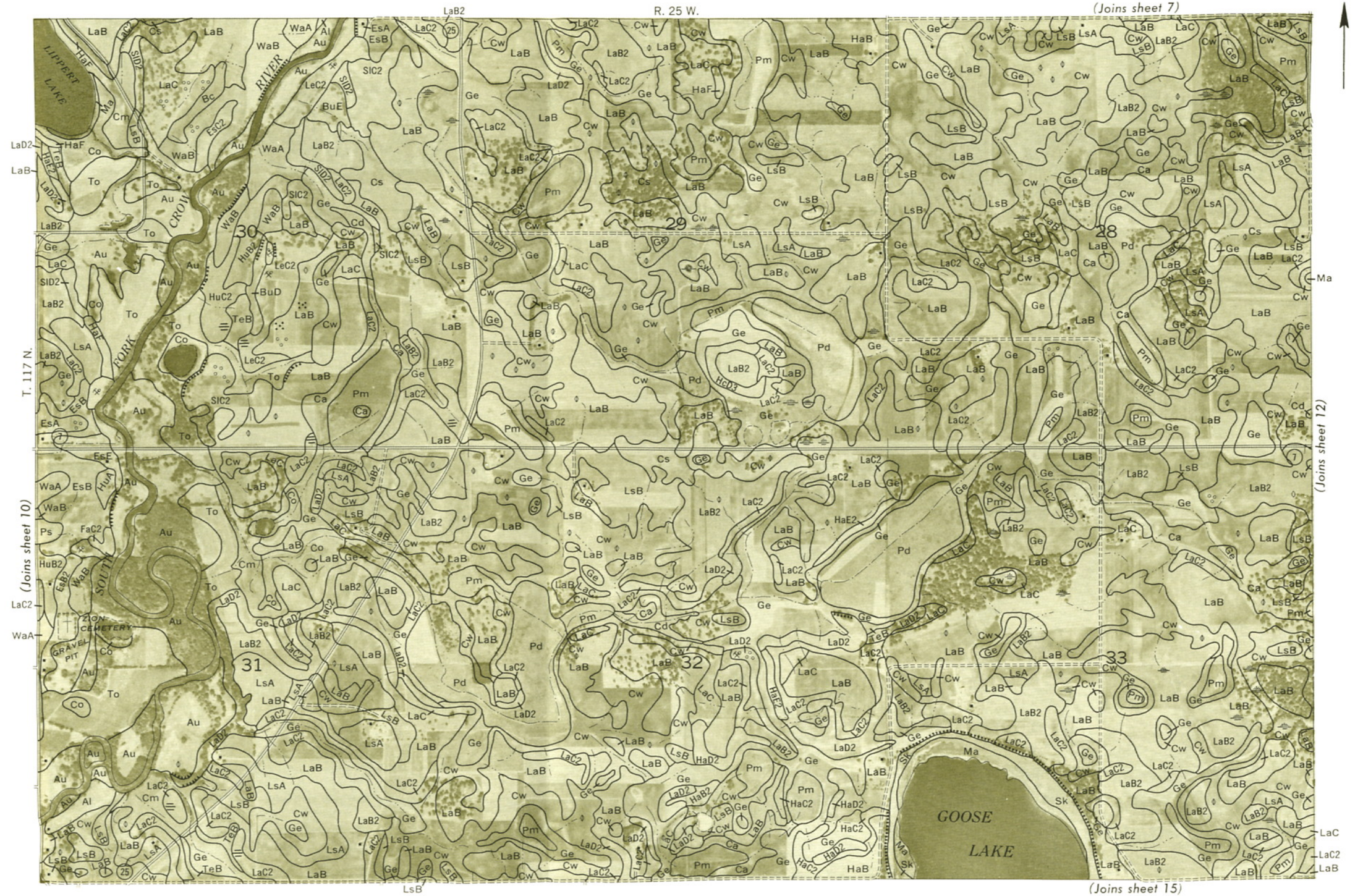
N
R. 25 W.
T. 117 N.
(Joins sheet 3)
(Joins sheet 5)
(Joins sheet 8)
(Joins sheet 11)
CROW
RIVER
GRAVEL PIT
TO FORK
SOUTH
LIPPERT LAKE
SWEDE LAKE
water
Swede Lake School
16
17
18
19
20
21

8

N
R. 25 W.
T. 117 N.
(Joins sheet 4)
(Joins sheet 7)
(Joins sheet 12)
HENNEPIN COUNTY
MUD LAKE
SWEDE LAKE
BUCK LAKE
OAK DALE
St. Peters School
Schapmann School
13
14
15
22
23
24

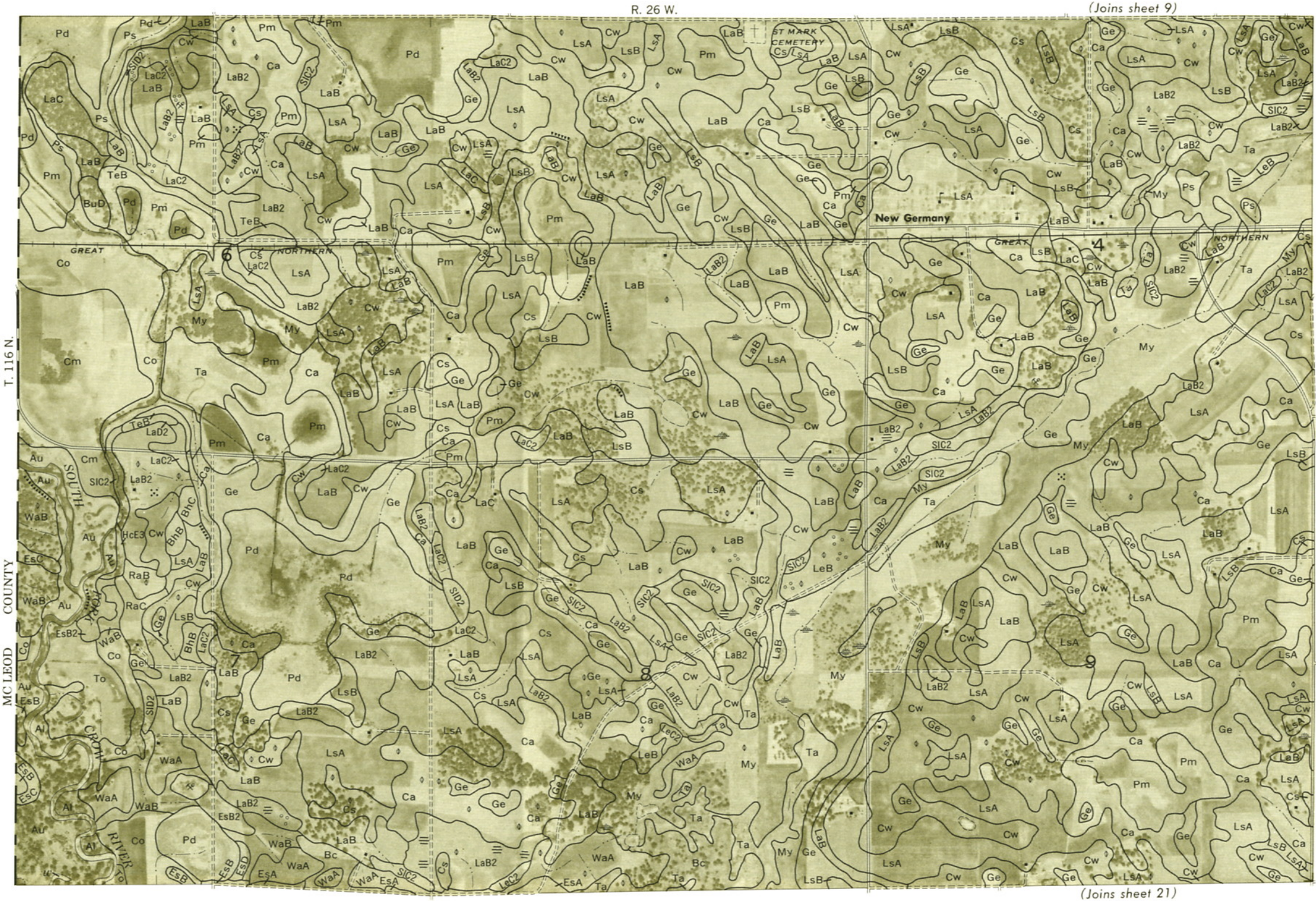
R. 26 W.
(Joins sheet 5)
N
T. 117 N.
MC LEOD COUNTY
(Joins sheet 10)
(Joins sheet 13)
Hollywood
GRAVEL PIT
Crane Creek
30
29
28
31
32
33

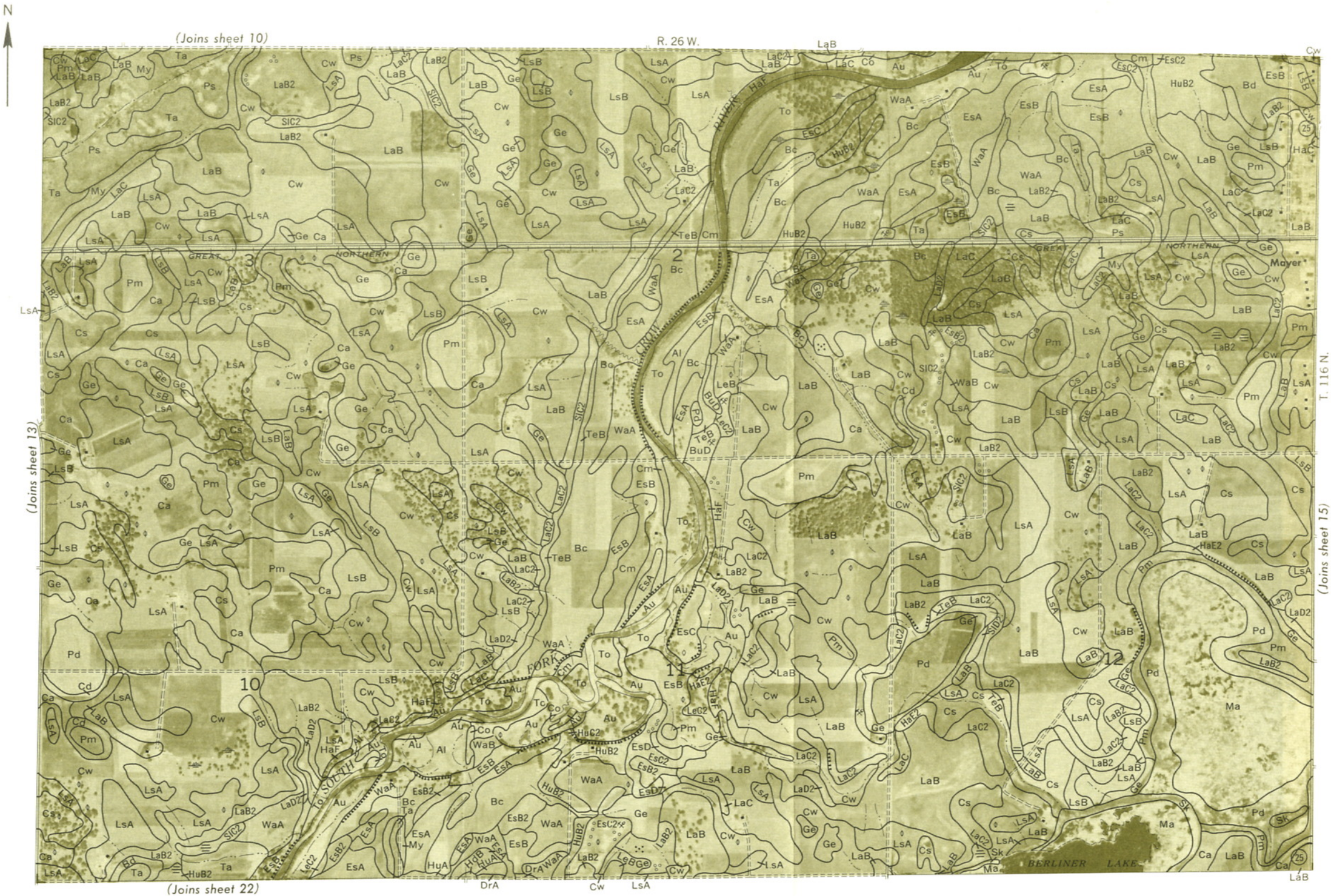
N
(Joins sheet 6)
R. 26 W.
T. 117 N.
(Joins sheet 9)
(Joins sheet 11)
(Joins sheet 14)
LIPPERT LAKE
27
26
25
34
35
36
GRAVEL PIT
CROW RIVER
SOUTH FORK


N
R. 25 W.
T. 117 N.
(Joins sheet 7)
(Joins sheet 10)
(Joins sheet 12)
(Joins sheet 15)
LIPPERT LAKE
CROW RIVER
SOUTH FORK
ZION CEMETERY
GRAVEL PIT
GOOSE LAKE
30
29
28
31
32
33

12

N
(Joins sheet 8)
R. 25 W.
BUCK LAKE
water
27
26
25
34
35
36
T. 117 N.
HENNEPIN COUNTY
(Joins sheet 11)
(Joins sheet 16)


N
R. 26 W.
(Joins sheet 9)
T. 116 N.
MC LEOD COUNTY
(Joins sheet 14)
(Joins sheet 21)
ST MARK CEMETERY
New Germany
GREAT NORTHERN
SOUTH FORK CROW RIVER
6
7
8
9
4


N
(Joins sheet 10)
R. 26 W.
T. 116 N.
(Joins sheet 13)
(Joins sheet 15)
(Joins sheet 22)
GREAT NORTHERN
RIVER
CREEK
SOUTH FORK
BERLINER LAKE
Mayer
1
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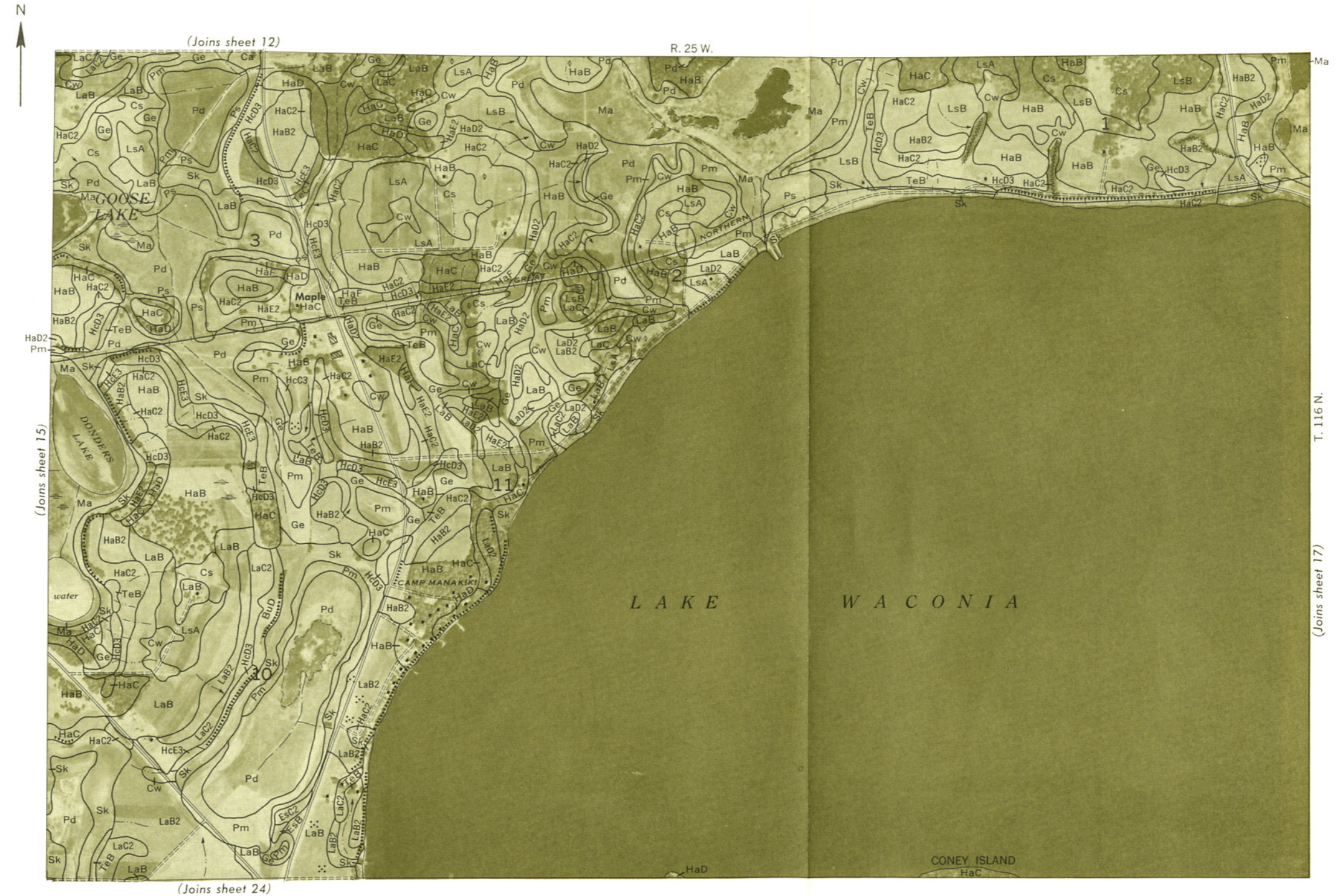
10
11
12

N
R. 25 W.
T. 116 N.
(Joins sheet 11)
(Joins sheet 14)
(Joins sheet 16)
(Joins sheet 23)
GOOSE LAKE
RUTZ LAKE
SWAN LAKE
RUTZ LAKE CEMETERY
GREAT NORTHERN
Moyer
water

16


N
(Joins sheet 12)
R. 25 W.
T. 116 N.
(Joins sheet 15)
(Joins sheet 17)
(Joins sheet 24)
GOOSE LAKE
DONDERS LAKE
LAKE WACONIA
CAMP MANAKIKI
CONEY ISLAND
Maple
GREAT NORTHERN
water
1
2
3
10
11

N

HENNEPIN COUNTY

R. 24 W.

T. 116 N.

PARLEY LAKE

LAKE

WACONIA

water

Seminary

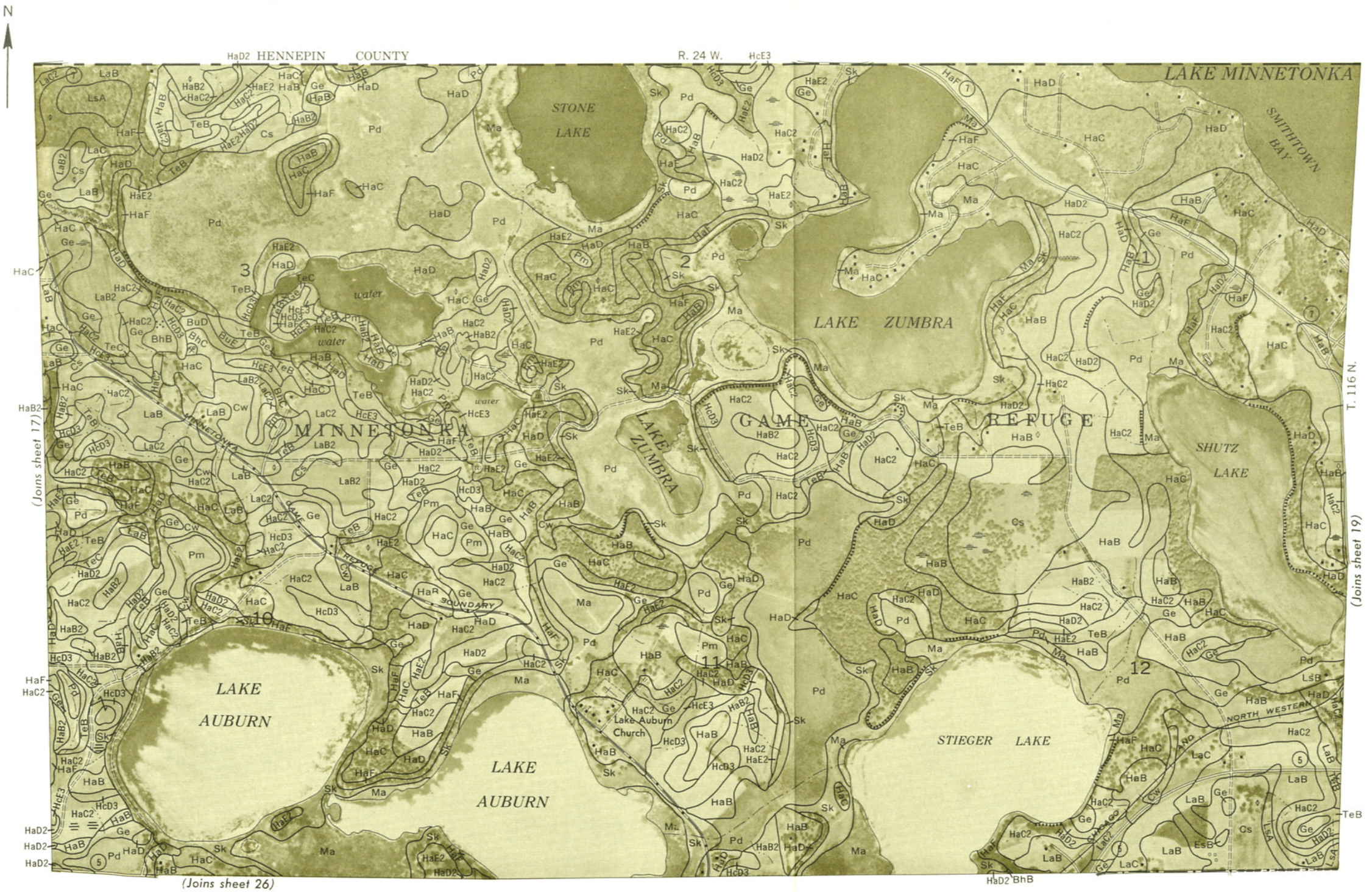
Jesuit

Scandia Church

(Joins sheet 16)

(Joins sheet 18)

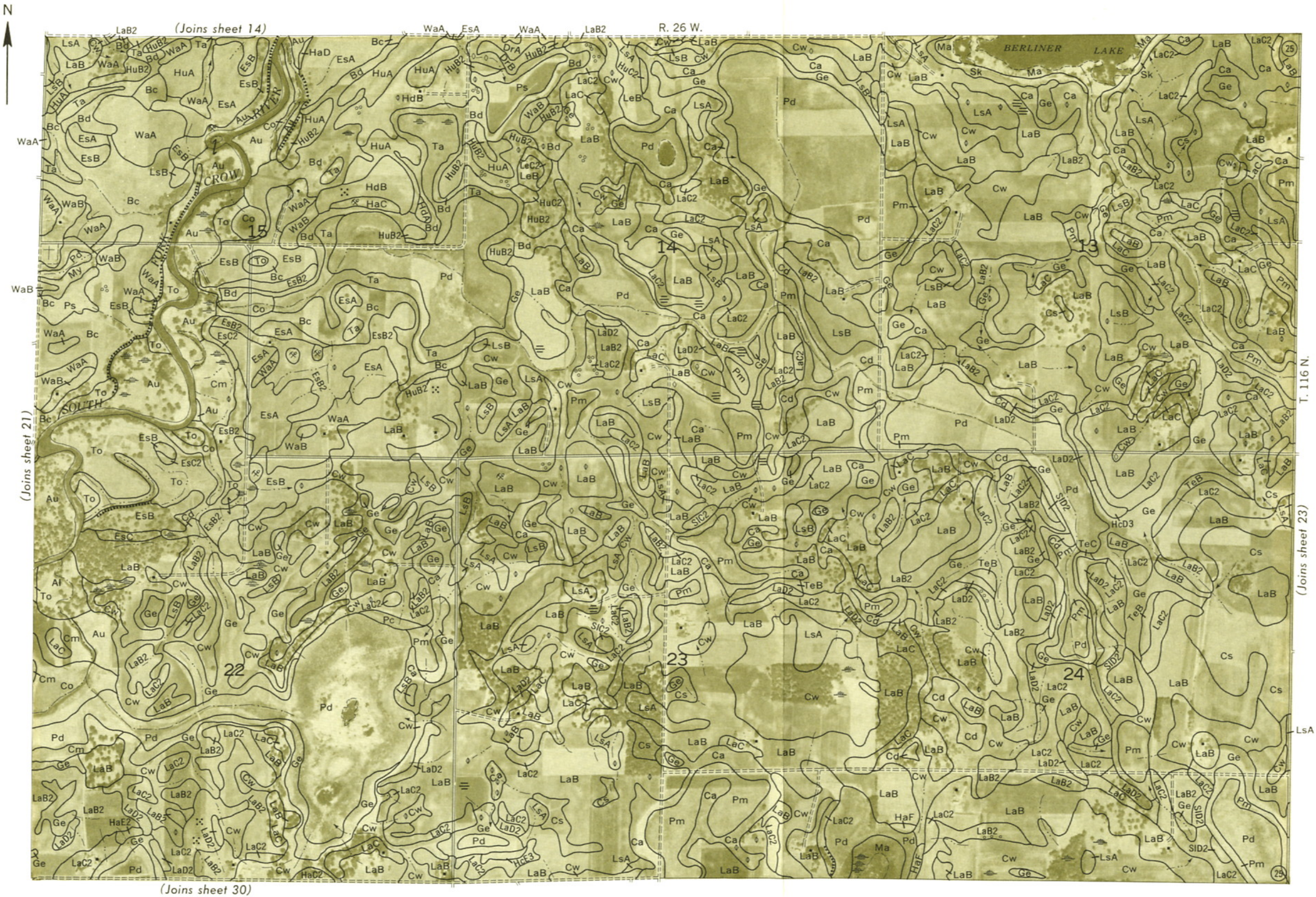
(Joins sheet 25)


18
N
HENNEPIN COUNTY
R. 24 W.
LAKE MINNETONKA
SMITHTOWN BAY
STONE LAKE
LAKE ZUMBRA
MINNETONKA
GAME REFUGE
SHUTZ LAKE
LAKE AUBURN
STIEGER LAKE
Lake Auburn Church
NORTH WESTERN
T. 116 N.
(Joins sheet 17)
(Joins sheet 19)
(Joins sheet 26)

HENNEPIN COUNTY
R. 23 W.
N
T. 116 N.
LAKE MINNETONKA
SMITHTOWN BAY
LAKE VIRGINIA
LAKE MINNEWASHTA
TAMARACK LAKE
LAKE ST JOE
MINNETONKA
University of Minnesota Fruit Breeding Farm
GAME REFUGE
REFUGE BOUNDARY
NORTH WESTERN
CHICAGO
(Joins sheet 18)
(Joins sheet 20)
(Joins sheet 27)

N
HENNEPIN COUNTY
R. 23 W.
T. 116 N.
HENNEPIN COUNTY
(Joins sheet 19)
(Joins sheet 28)
CHRISTMAS LAKE
LOTUS LAKE
LAKE LUCY
LAKE ANN
HARRISON LAKE
MINNETONKA GAME REFUGE
Carver Beach
Chanhassen
BOUNDARY
1
2
3
10
11
12

N
R. 26 W.
(Joins sheet 13)
(Joins sheet 22)
(Joins sheet 29)
T. 116 N.
MC LEOD COUNTY
SOUTH CREEK
BUFFALO CREEK
CROW RIVER
GRAVEL PIT
18
19
20
21
16


N
(Joins sheet 14)
R. 26 W.
BERLINER LAKE
CROW RIVER
SOUTH
(Joins sheet 21)
T. 116 N.
(Joins sheet 23)
(Joins sheet 30)
13
14
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22
23
24

R. 25 W.
T. 116 N.
N
(Joins sheet 15)
(Joins sheet 22)
(Joins sheet 24)
(Joins sheet 31)
LAKE PATTERSON
16
17
18
19
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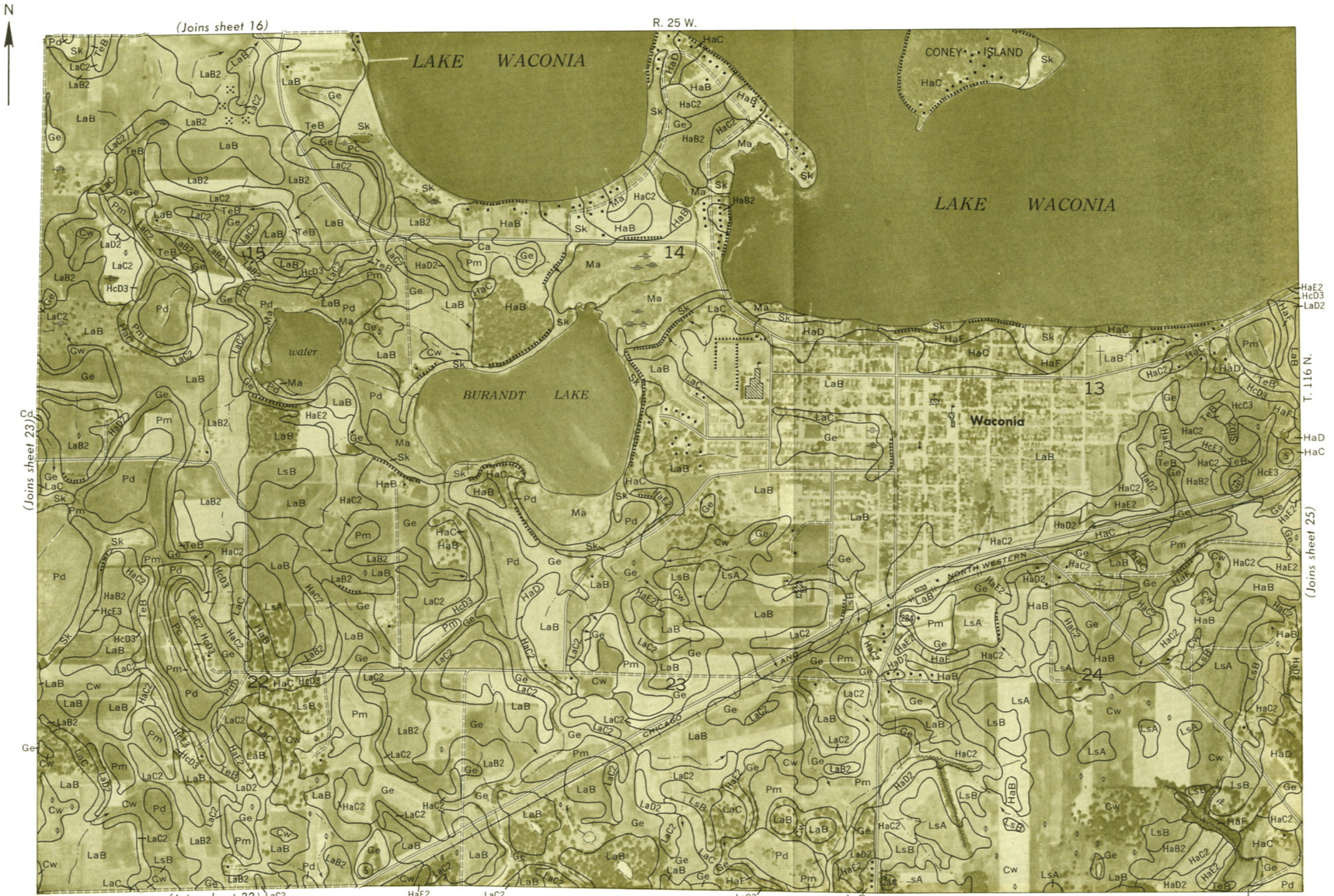
21

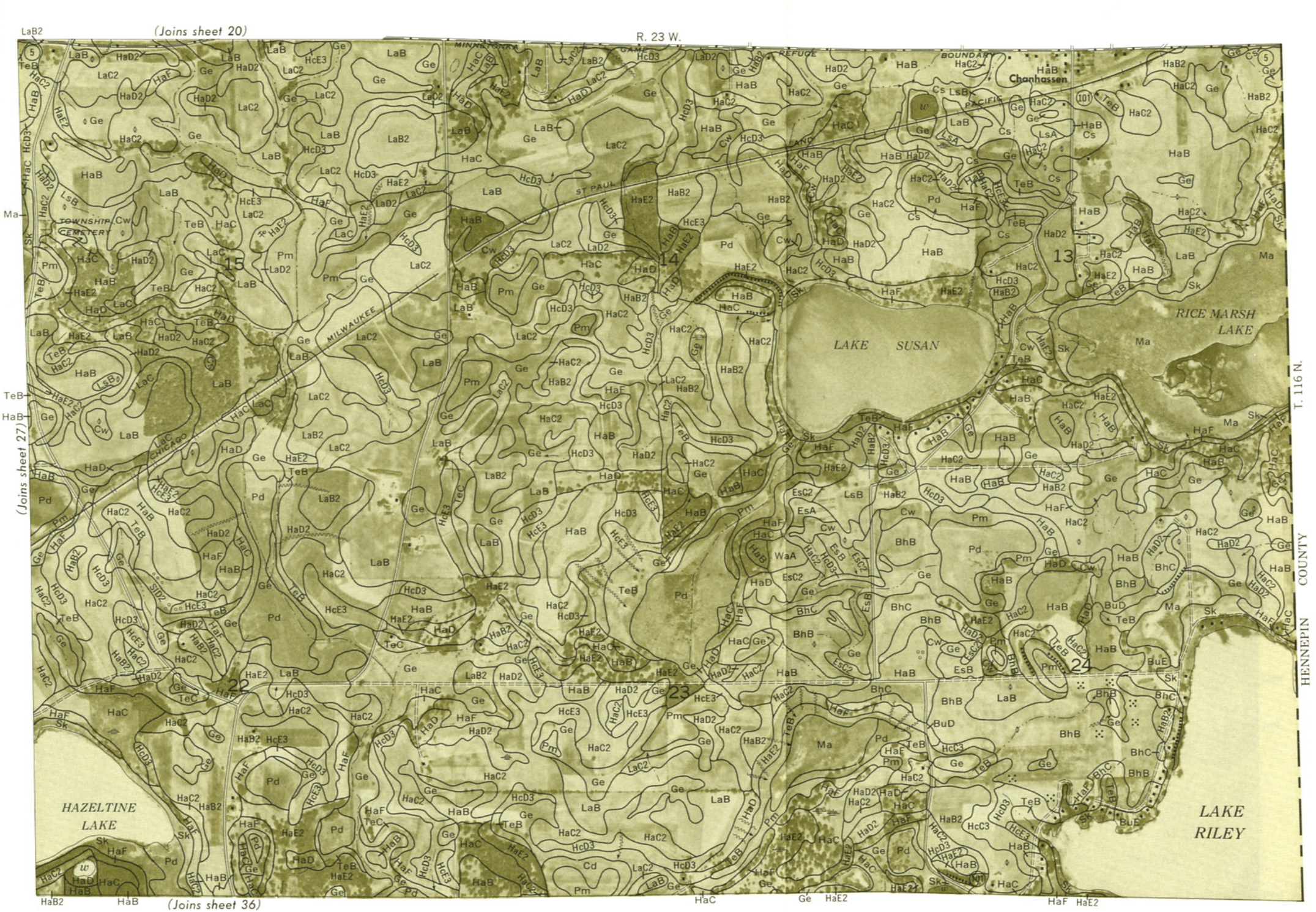

N
(Joins sheet 16)
R. 25 W.
LAKE WACONIA
CONEY ISLAND
LAKE WACONIA
BURANDT LAKE
water
Waconia
15
14
13
22
23
24
T. 116 N.
NORTH WESTERN
CHICAGO
(Joins sheet 23)
(Joins sheet 25)
(Joins sheet 32)

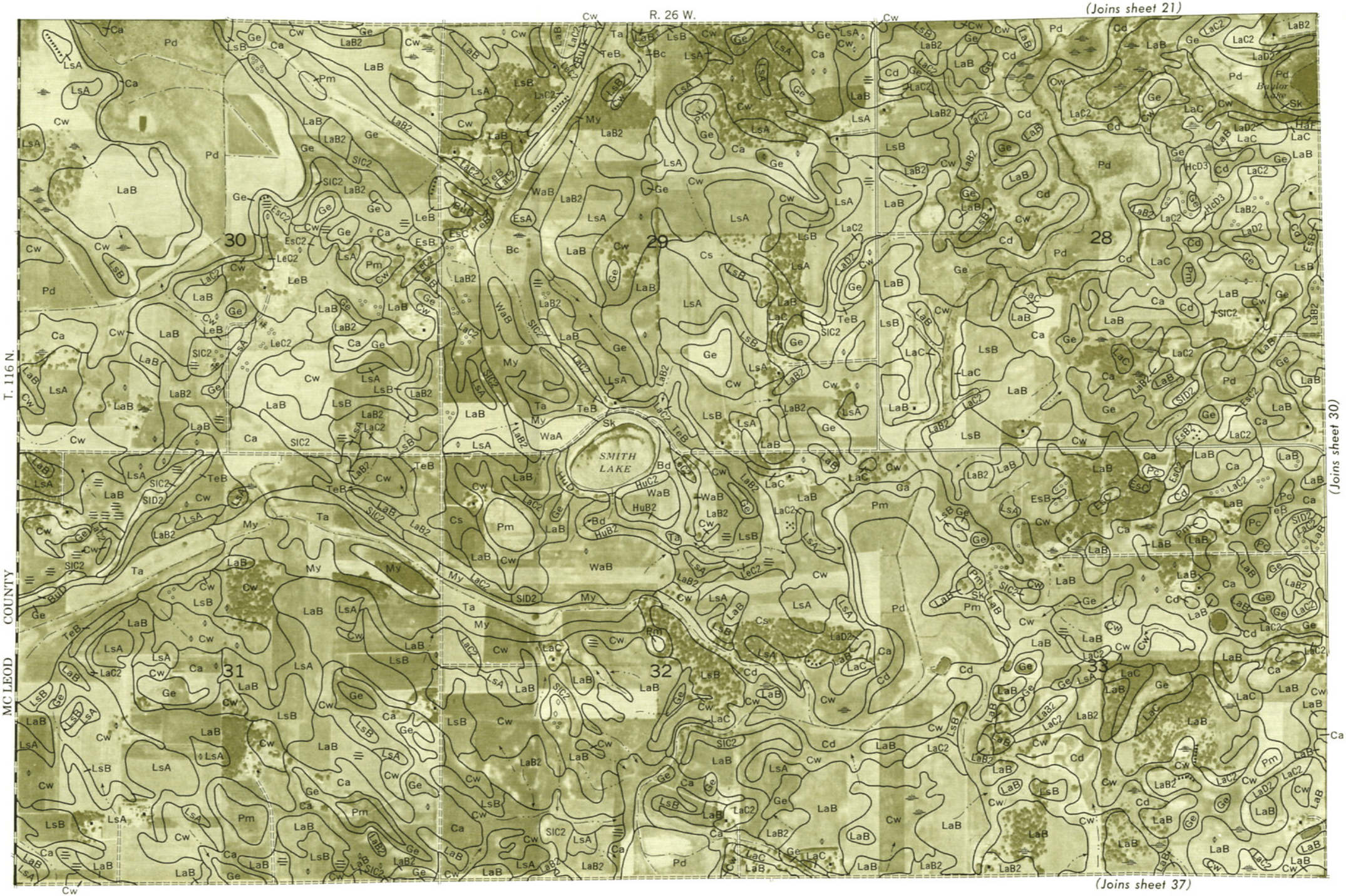
R. 24 W.
(Joins sheet 17)
N
T. 116 N.
LAKE WACONIA
Coney Island
REITZ LAKE
TURBID LAKE
PIERSONS LAKE
CHICAGO AND NORTH WESTERN
17
18
19
20
21
16
(Joins sheet 24)
(Joins sheet 26)
(Joins sheet 33)

N
(Joins sheet 18)
R. 24 W.
T. 116 N.
(Joins sheet 25)
(Joins sheet 27)
(Joins sheet 34)
LAKE AUBURN
STIEGER LAKE
CARL KREY LAKE
WATERMAN LAKE
PIERSONS LAKE
LAKE BAVARIA
MINNETONKA
NORTH WESTERN
CHICAGO
GAME REFUGE AND BOUNDARY
Victoria
water
15
14
13
22
23
24

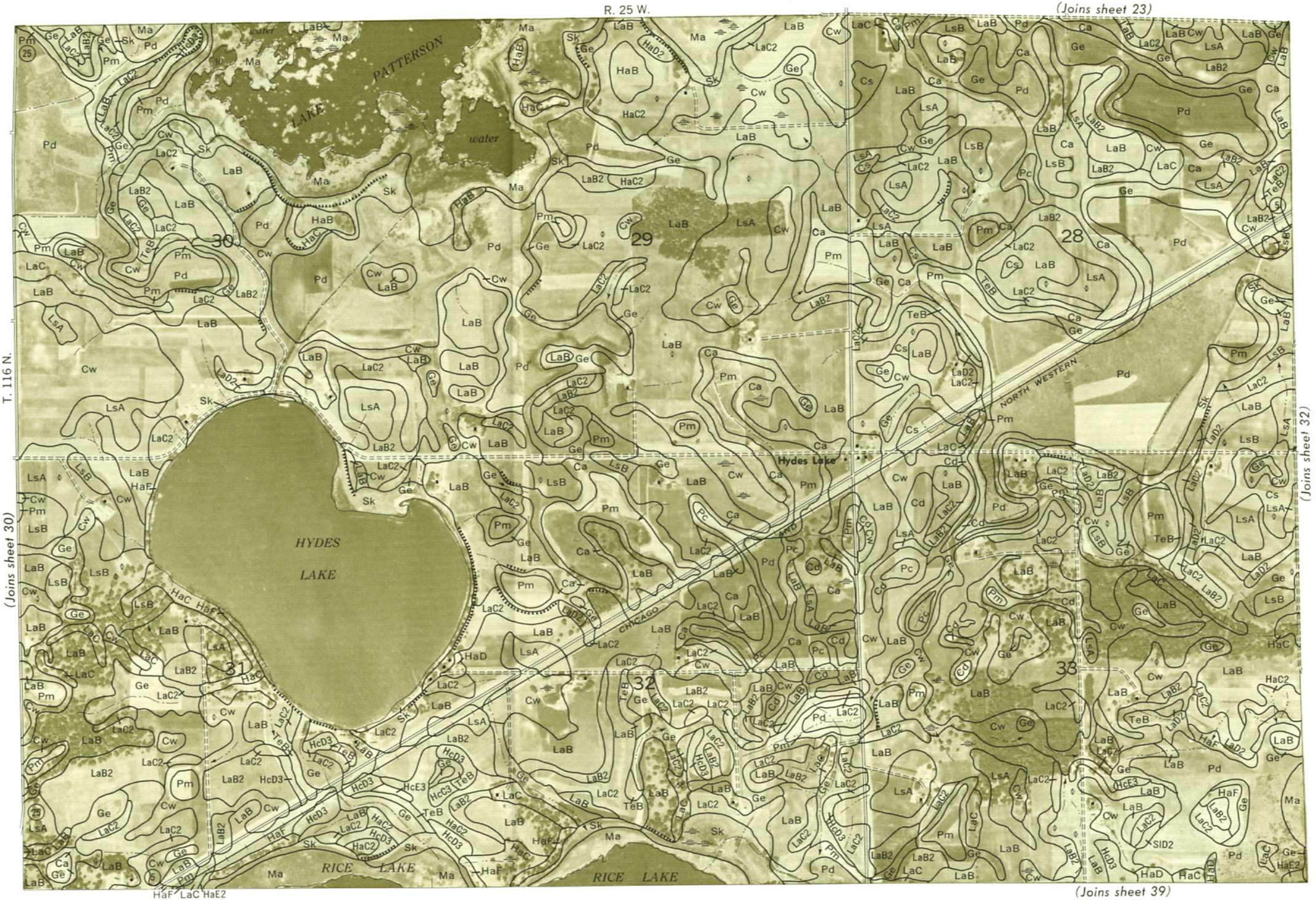
N
R. 23 W.
T. 116 N.
(Joins sheet 19)
(Joins sheet 26)
(Joins sheet 28)
(Joins sheet 35)
17
18
16
19
20
21
LAKE BAVARIA
HAZELTINE LAKE
Hazeltine
water
water

28

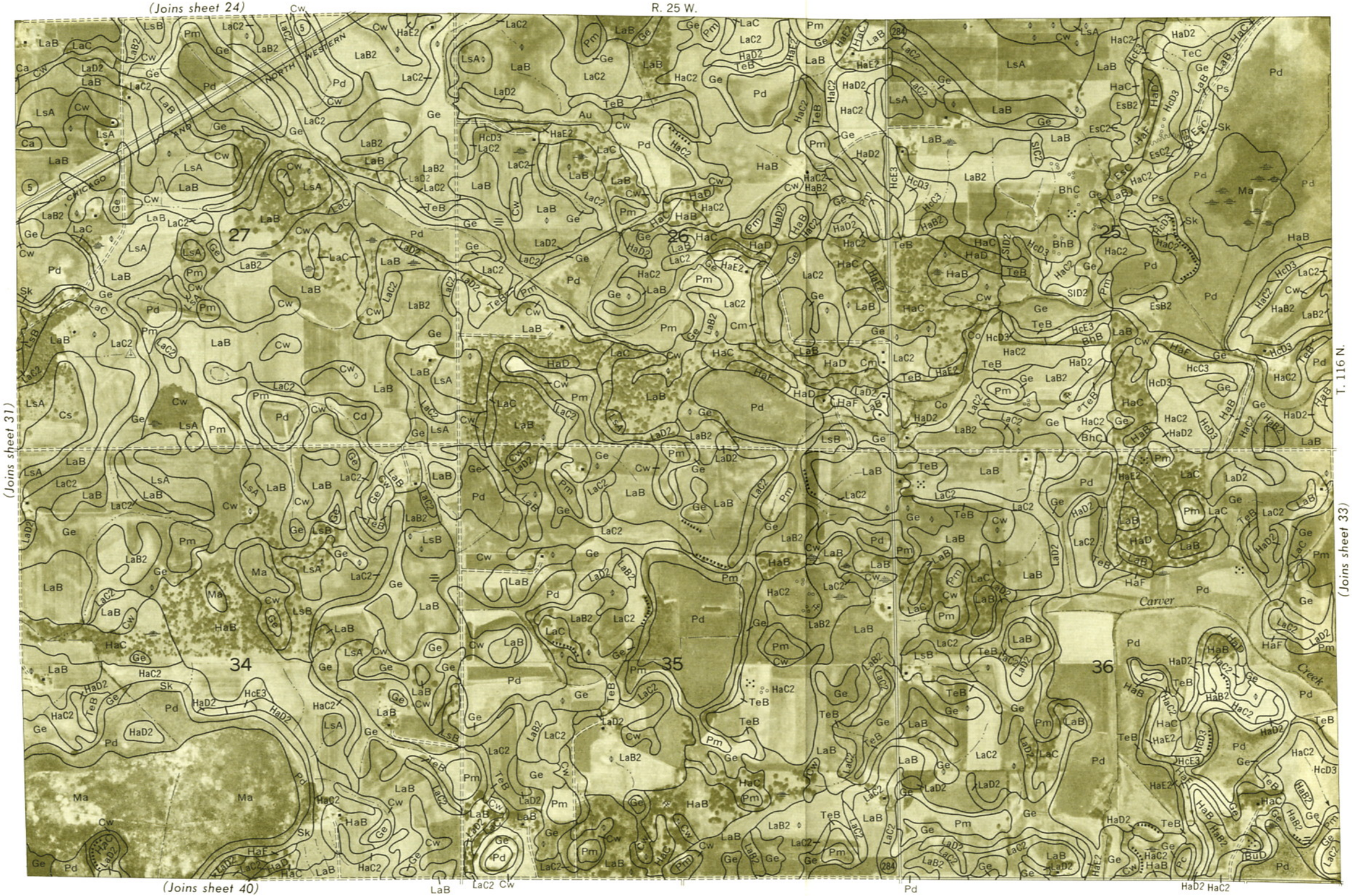

N
(Joins sheet 20)
R. 23 W.
(Joins sheet 27)
(Joins sheet 36)
T. 116 N.
HENNEPIN COUNTY
LAKE SUSAN
RICE MARSH LAKE
HAZELTINE LAKE
LAKE RILEY
Chanhassen
MILWAUKEE
CHICAGO
ST PAUL
PACIFIC
TOWNSHIP CEMETERY
13
14
15
22
23
24


N
R. 26 W.
(Joins sheet 21)
T. 116 N.
MC LEOD COUNTY
(Joins sheet 30)
(Joins sheet 37)
SMITH LAKE
30
29
28
31
32
33

30
N
(Joins sheet 22)
R. 26 W.
(Joins sheet 29)
(Joins sheet 31)
T. 116 N.
(Joins sheet 38)
Baylor Lake
EAGLE LAKE
25
26
27
34
35
36


N
R. 25 W.
(Joins sheet 23)
T. 116 N.
(Joins sheet 30)
(Joins sheet 32)
(Joins sheet 39)
PATTERSON LAKE
water
HYDES LAKE
Hydes Lake
RICE LAKE
RICE LAKE
CHICAGO
NORTH WESTERN
30
29
28
31
32
33

32


N
(Joins sheet 24)
R. 25 W.
T. 116 N.
(Joins sheet 31)
(Joins sheet 33)
(Joins sheet 40)
CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC
NORTH WESTERN
27
26
25
34
35
36
Carver
Creek

CARVER COUNTY, MINNESOTA — SHEET NUMBER 33

33

N

R. 24 W.

(Joins sheet 25)

T. 116 N.

(Joins sheet 32)

(Joins sheet 34)

(Joins sheet 41)

PIERSONS LAKE

Carver Creek

29

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28

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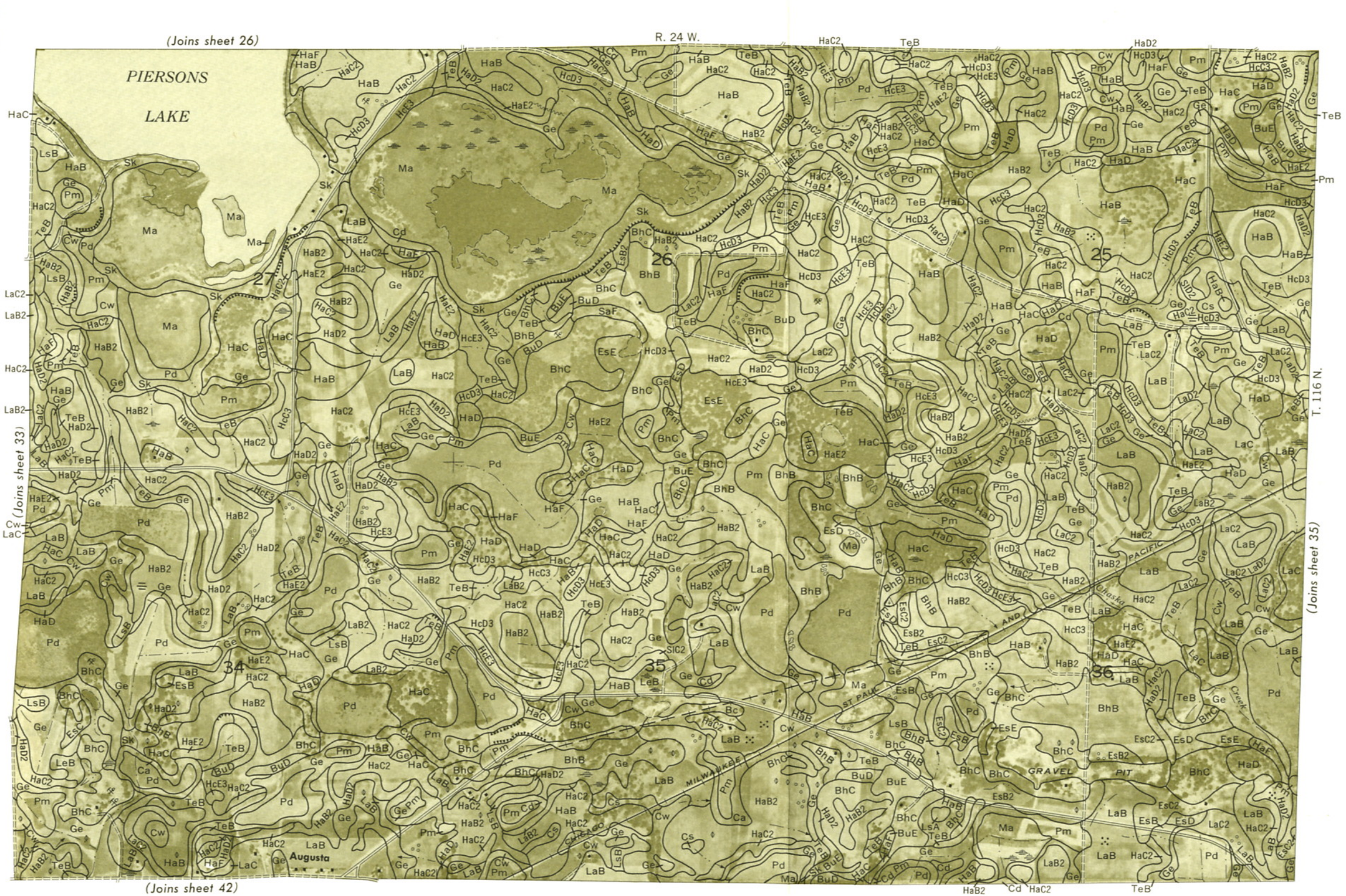
33


N
(Joins sheet 26)
R. 24 W.
PIERSONS
LAKE
(Joins sheet 33)
(Joins sheet 35)
(Joins sheet 42)
T. 116 N.
Augusta
CHICAGO, MILWAUKEE, ST PAUL AND PACIFIC
GRAVEL PIT
Creek
26
25
27
34
35
36

N
R. 23 W.
(Joins sheet 27)
(Joins sheet 34)
(Joins sheet 36)
(Joins sheet 43)
T. 116 N.
LAKE BAVARIA
MILWAUKEE
CHICAGO
GRAVEL PIT
GRAVEL PIT
30
29
28
31
32
33

N
(Joins sheet 28)
R. 23 W.
LAKE RILEY
T. 116 N.
(Joins sheet 35)
(Joins sheet 44)
SCOTT COUNTY
HENNEPIN COUNTY
RICE LAKE
Bluff Creek
CHICAGO AND NORTH WESTERN
Assumption Seminary
25
26
27
34
35
36

R. 26 W.
(Joins sheet 29)
N
T. 115 N.
MC LEOD COUNTY
(Joins sheet 38)
(Joins sheet 45)
Frieden Church
FERGUSON CEMETERY
TIGER LAKE
TIGER LAKE

38
N
(Joins sheet 30)
R. 26 W.
(Joins sheet 37)
(Joins sheet 39)
(Joins sheet 46)
T. 115 N.
Young America
Brownworth Lake
YOUNG AMERICA LAKE
BARNES LAKE
TIGER LAKE
CHICAGO AND NORTH WESTERN
1
2
3
10
11
12

R. 25 W.
(Joins sheet 31)
N
T. 115 N.
(Joins sheet 38)
(Joins sheet 40)
(Joins sheet 47)
RICE LAKE
BARLOUS LAKE
MYERS LAKE
WINKLER LAKE
5
6
7
8
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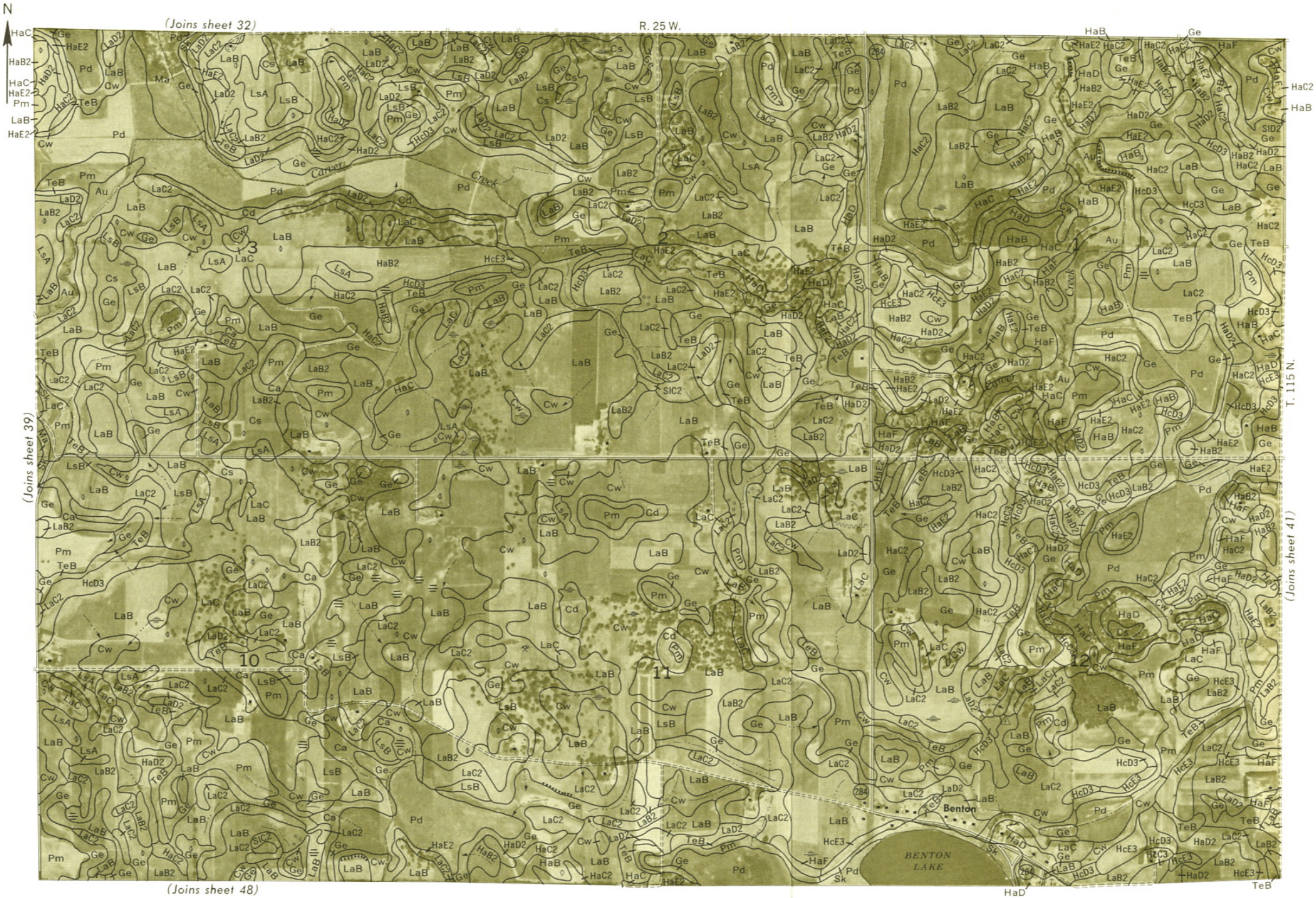
40
N
(Joins sheet 32)
R. 25 W.
(Joins sheet 39)
(Joins sheet 41)
(Joins sheet 48)
T. 115 N.
Carver Creek
Benton
BENTON LAKE
1
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N
R. 24 W.
(Joins sheet 33)
(Joins sheet 40)
(Joins sheet 42)
(Joins sheet 49)
T. 115 N.
MILLER
LAKE
AUE
LAKE
Carver
Creek
CHICAGO
MILWAUKEE
AND
PACIFIC
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N

(Joins sheet 34)

R. 24 W.

T. 115 N.

(Joins sheet 41)

(Joins sheet 43)

(Joins sheet 50)

Augusta

PACIFIC

ST PAUL

MILWAUKEE

CHICAGO

AUE LAKE

water

Dahlgren

Church

Zoar

1

2

3

10

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12

N
R. 23 W.
T. 115 N.
(Joins sheet 35)
(Joins sheet 44)
(Joins sheet 42)
(Joins sheet 51)
Chaska
(county seat)
CHASKA LAKE
MINNESOTA
SCOTT
COUNTY
RIVER
MORAVIAN CEMETERY
CLAY PIT
DUMP
NORTH WESTERN
PACIFIC
MILWAUKEE
CHICAGO
Chuska
Creek
water

N
(Joins sheet 36)
R. 23 W.
(Joins sheet 43)
T. 115 N.
212
CHICAGO AND NORTH WESTERN
ST JOHNS CEMETERY
DUMP
MINNESOTA RIVER
SCOTT COUNTY
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Al
HdA
HdB
HdC
HdD
EsA
EsD
WaB
Bd
Ch
Ps
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SaF

N
R. 26 W.
(Joins sheet 37)
TIGER LAKE
T. 115 N.
MC LEOD COUNTY
(Joins sheet 46)
(Joins sheet 52)
CHICAGO MILWAUKEE ST. PAUL PACIFIC
16
17
18
19
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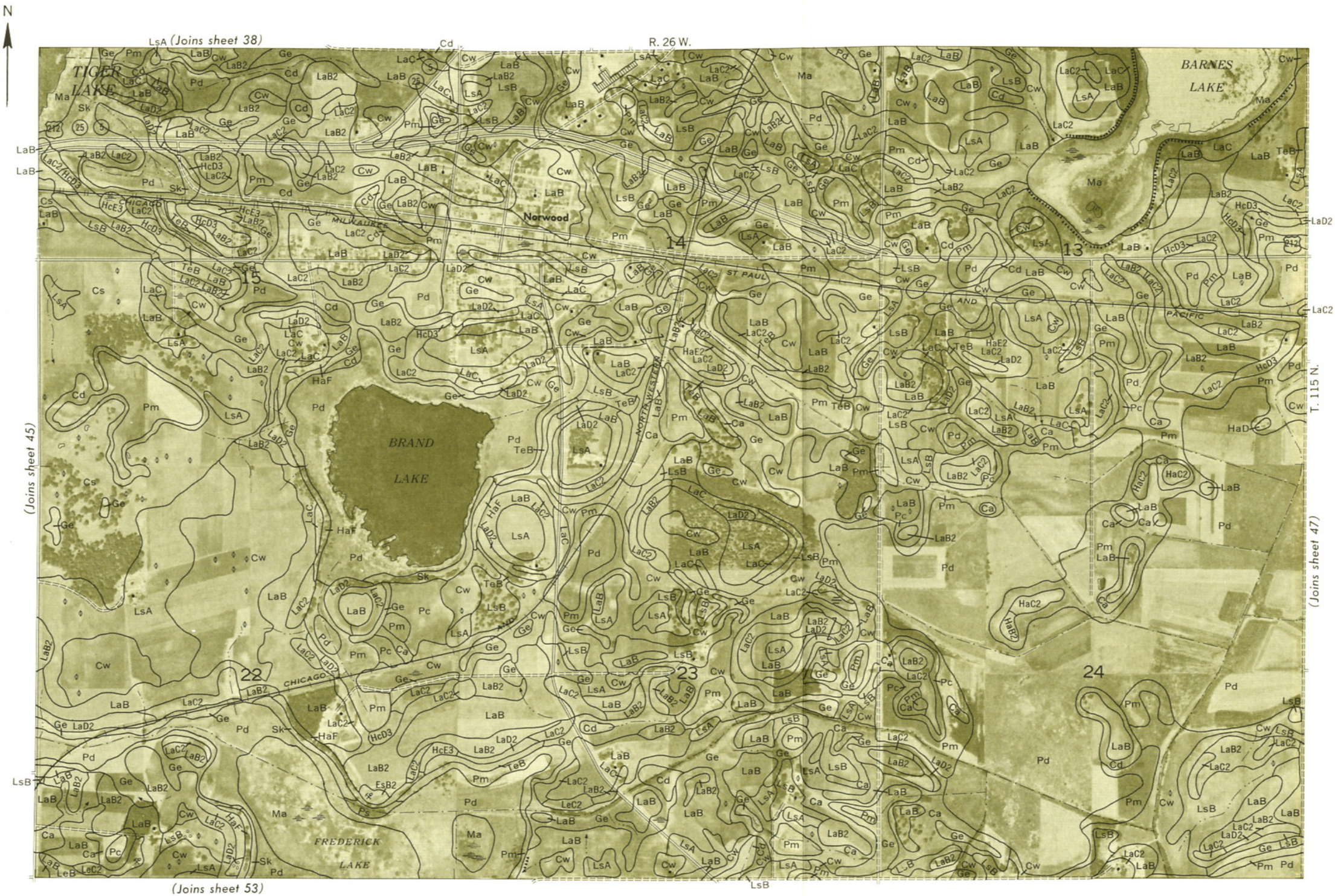
21


N
LsA (Joins sheet 38)
R. 26 W.
TIGER LAKE
BARNES LAKE
Norwood
BRAND LAKE
FREDERICK LAKE
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
NORTHWESTERN
CHICAGO
13
14
15
22
23
24
T. 115 N.
(Joins sheet 45)
(Joins sheet 47)
(Joins sheet 53)

N
R. 25 W.
(Joins sheet 39)
T. 115 N.
(Joins sheet 46)
(Joins sheet 48)
(Joins sheet 54)
MYERS LAKE
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
Bongards
16
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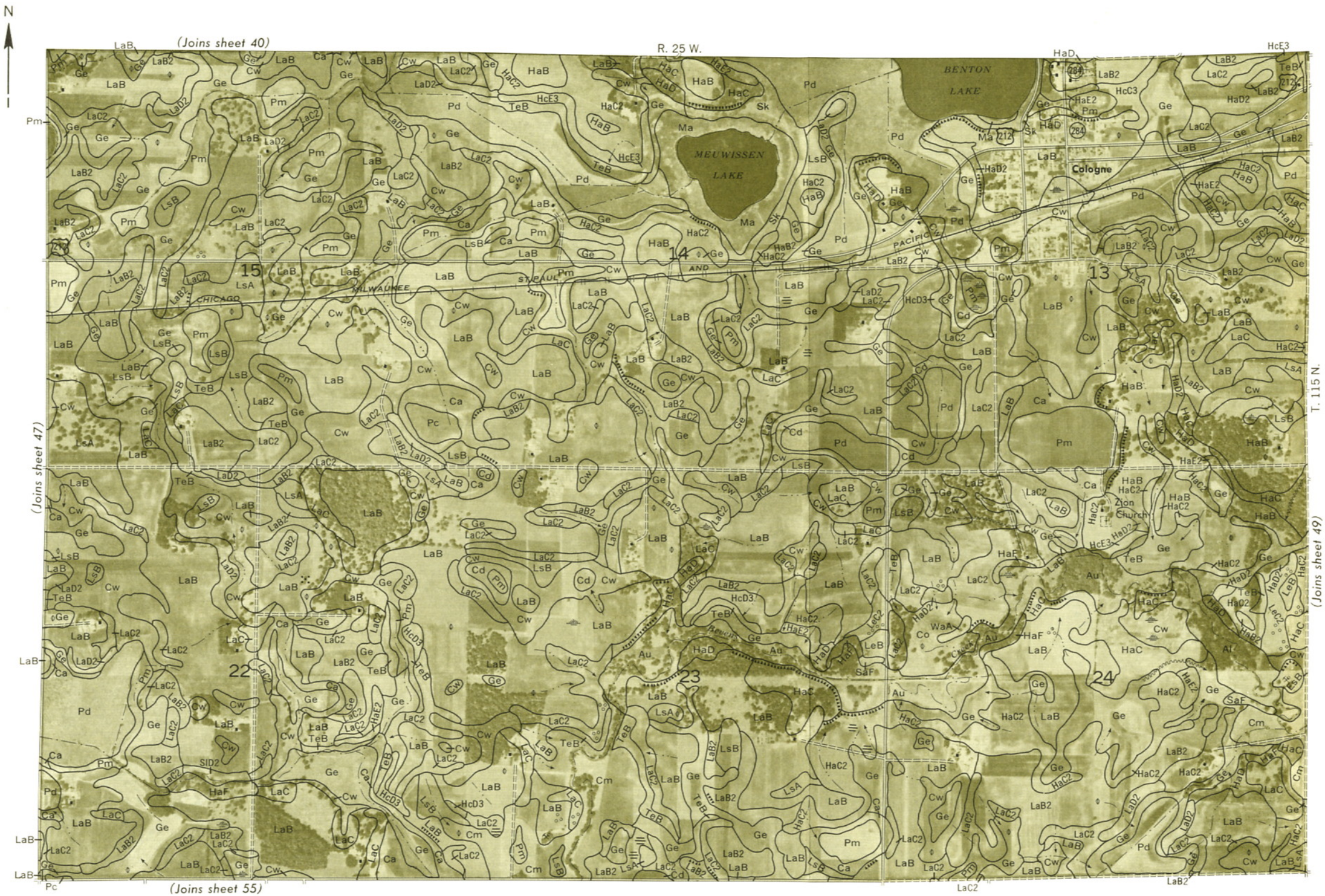
N
(Joins sheet 40)
R. 25 W.
BENTON LAKE
MEUWISSEN LAKE
Cologne
Zion Church
MILWAUKEE ST.PAUL AND PACIFIC CHICAGO
15
14
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24
T. 115 N.
(Joins sheet 47)
(Joins sheet 49)
(Joins sheet 55)

N
R. 24 W.
Joins sheet 41)
T. 115 N.
(Joins sheet 48)
(Joins sheet 50)
(Joins sheet 56)
MILWAUKEE
CHICAGO
ST PAUL
AND
PACIFIC
Carver
Creek
Bevens
Creek
16
17
18
19
20
21

N
(Joins sheet 42)
R. 24 W.
T. 115 N.
(Joins sheet 49)
(Joins sheet 51)
(Joins sheet 57)
Dahlgren
CHICAGO
MILWAUKEE
PACIFIC
GRAVEL PIT
GRAVEL PIT
ST NICKOLAS CEMETERY
Creek
Creek
15
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24

N
R. 23 W.
(Joins sheet 43)
(Joins sheet 50)
(Joins sheet 58)
T. 115 N.
CHASKA LAKE
MT HOPE CEMETERY
Carver
Carver Creek
MINNESOTA RIVER
SCOTT COUNTY
SCOTT COUNTY
CHICAGO MILWAUKEE
ST PAUL AND NORTH PACIFIC
CHICAGO AND NORTH WESTERN
16
17
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52

N
(Joins sheet 45)
R. 26 W.
T. 115 N.
(Joins sheet 53)
MC LEOD COUNTY
SIBLEY COUNTY
Hamburg
Emmanuel School
GRAVEL PIT
NORTH WESTERN
CHICAGO AND
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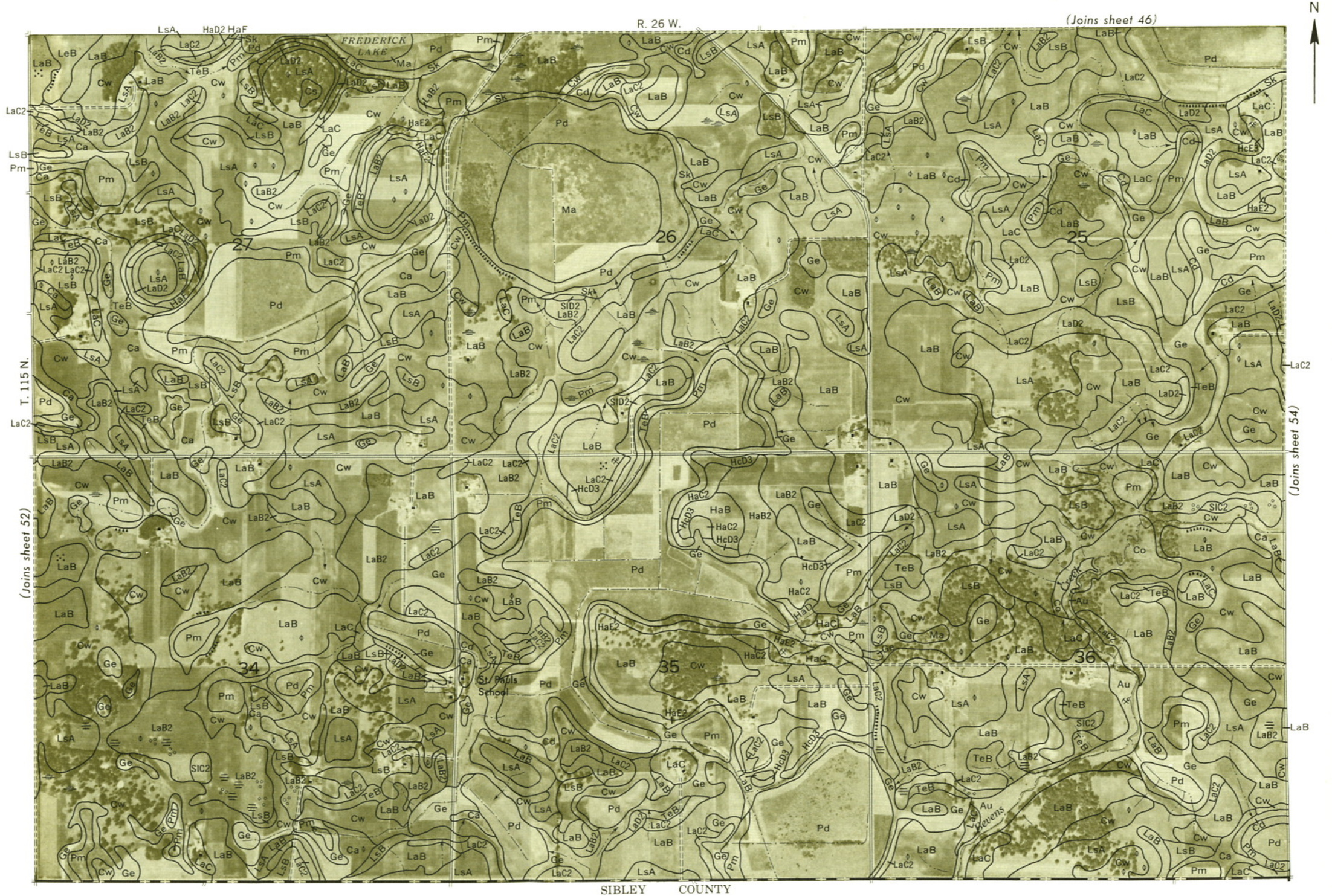
33


N
R. 26 W.
(Joins sheet 46)
(Joins sheet 54)
(Joins sheet 52)
T. 115 N.
FREDERICK LAKE
St. Pauls School
Bevens Creek
27
26
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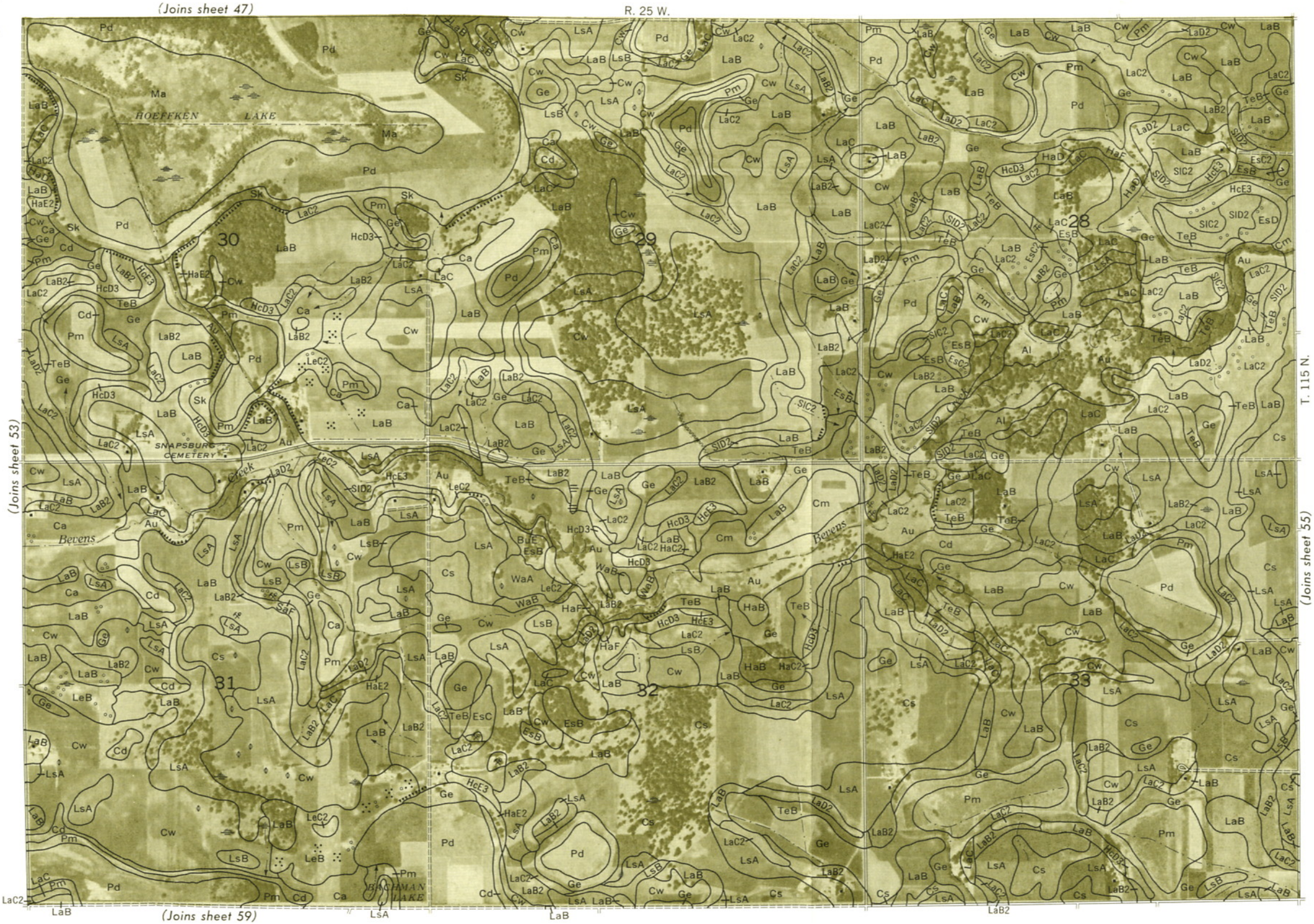
36
SIBLEY COUNTY


N
(Joins sheet 47)
R. 25 W.
T. 115 N.
(Joins sheet 53)
(Joins sheet 55)
(Joins sheet 59)
HOEFKEN LAKE
SNAPSBURG CEMETERY
Bevens Creek
BENHAM LAKE
30
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33

R. 25 W.
(Joins sheet 48)
T. 115 N.
(Joins sheet 54)
(Joins sheet 56)
(Joins sheet 60)
N
27
26
25
34
35
36
Zion School
Bevens Creek
MARIA LAKE
Gotha

N

(Joins sheet 49)

R. 24 W.

T. 115 N.

(Joins sheet 55)

(Joins sheet 57)

(Joins sheet 61)

Bevens Creek

AUGUSTANA CEMETERY

MARIA LAKE

29 28 30 31 32 33

N

R. 24 W.

(Joins sheet 50)

T. 115 N.

(Joins sheet 56)

(Joins sheet 58)

(Joins sheet 62)

East Union

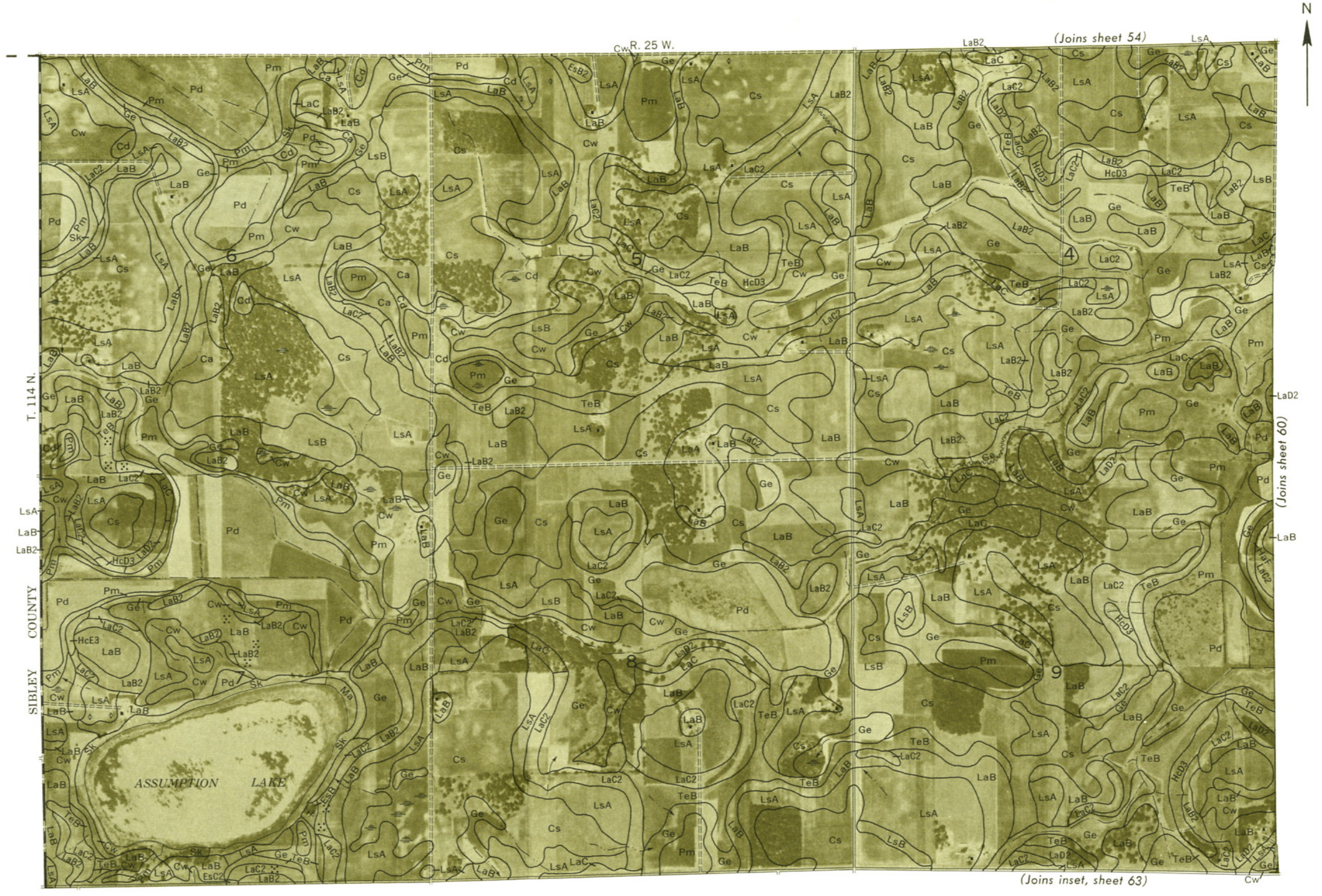
water

(58)

N
(Joins sheet 51)
R. 23 W.
T. 115 N.
(Joins sheet 57)
(Joins inset above)
SCOTT COUNTY
MINNESOTA RIVER
Rapid Lake
Carver Rapids
30
31
HuC2
SaF
HdB
EsD
KaB2
TeB
HuD
KaA
HdD
KsA
EsC
RaB
RaC
Sc
Ch
Os
Al
Au
FaA
EsB
FaC2
DrA

N

(Joins lower left)
R. 23 W.
T. 114 N.
(Joins sheet 62)
LONG LAKE
HORSESHOE LAKE
MINNESOTA RIVER
SCOTT COUNTY
5
6
7
DrA
FaA
KaA
KaB2
KsA
KsB2
RaB
SaF
EsB
EsC2
HuC2
HuD
FeB
DrB
FaB
WaA
HdF
Os
Ch
Al
Au
Sc
Ta
WaB
WaC2
FaC2


N
R. 25 W.
T. 114 N.
SIBLEY COUNTY
(Joins sheet 54)
(Joins sheet 60)
(Joins inset, sheet 63)
ASSUMPTION LAKE
6
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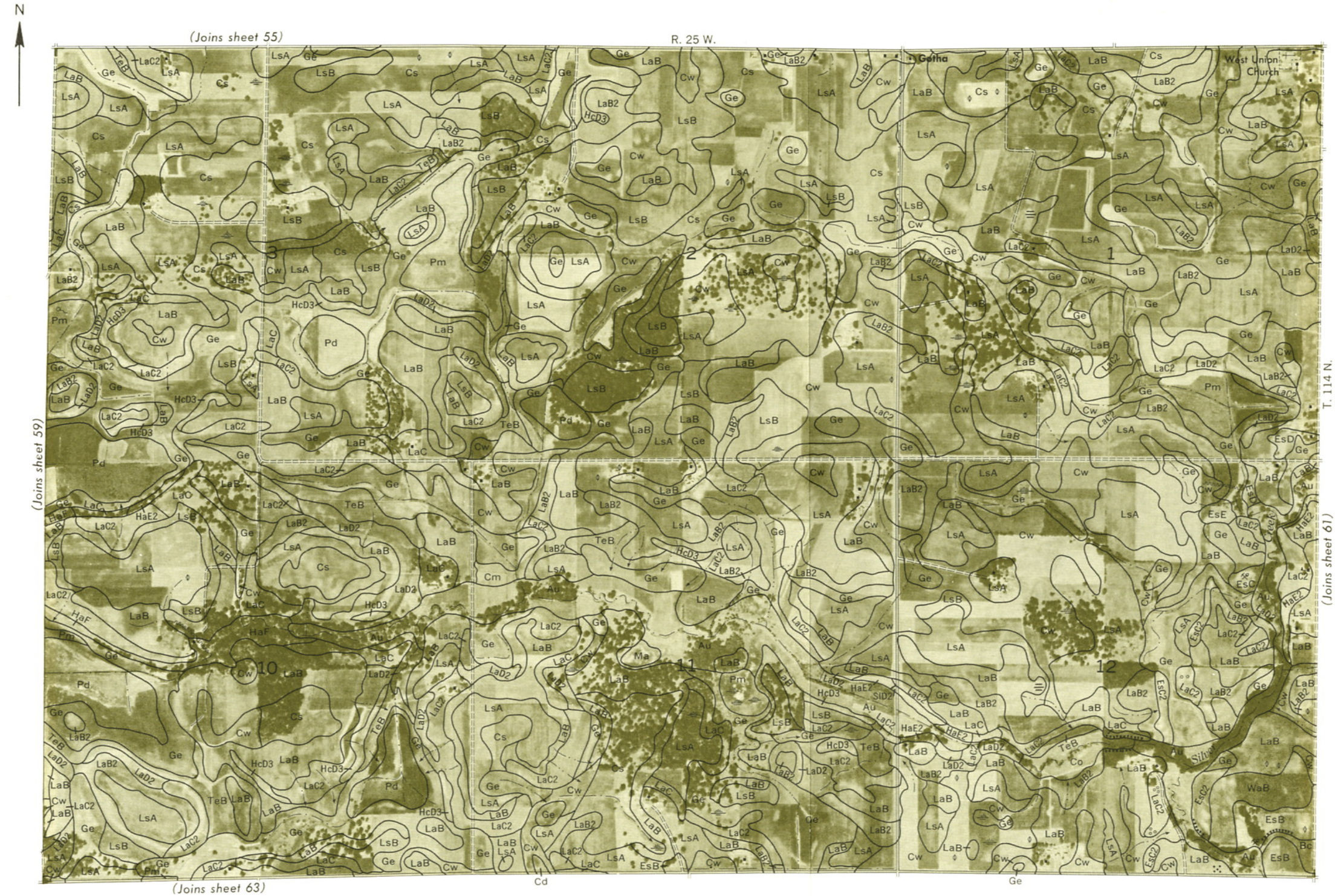
N
(Joins sheet 55)
R. 25 W.
Geitha
West Union Church
(Joins sheet 59)
T. 114 N.
(Joins sheet 61)
(Joins sheet 63)
Cd
Ge
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N

R. 24 W.

(Joins sheet 56)

T. 114 N.

(Joins sheet 60)

(Joins sheet 62)

(Joins sheet 64)

Silver Creek

GRAVEL PIT

N
(Joins sheet 57)
R. 24 W.
East Union
(Joins sheet 61)
(Joins inset, sheet 58)
(Joins inset, sheet 65)
T. 114 N.
Silver Creek
Bevens Creek
LONG LAKE
LUNDQUIST LAKE
MINNESOTA RIVER
SCOTT COUNTY
water
1
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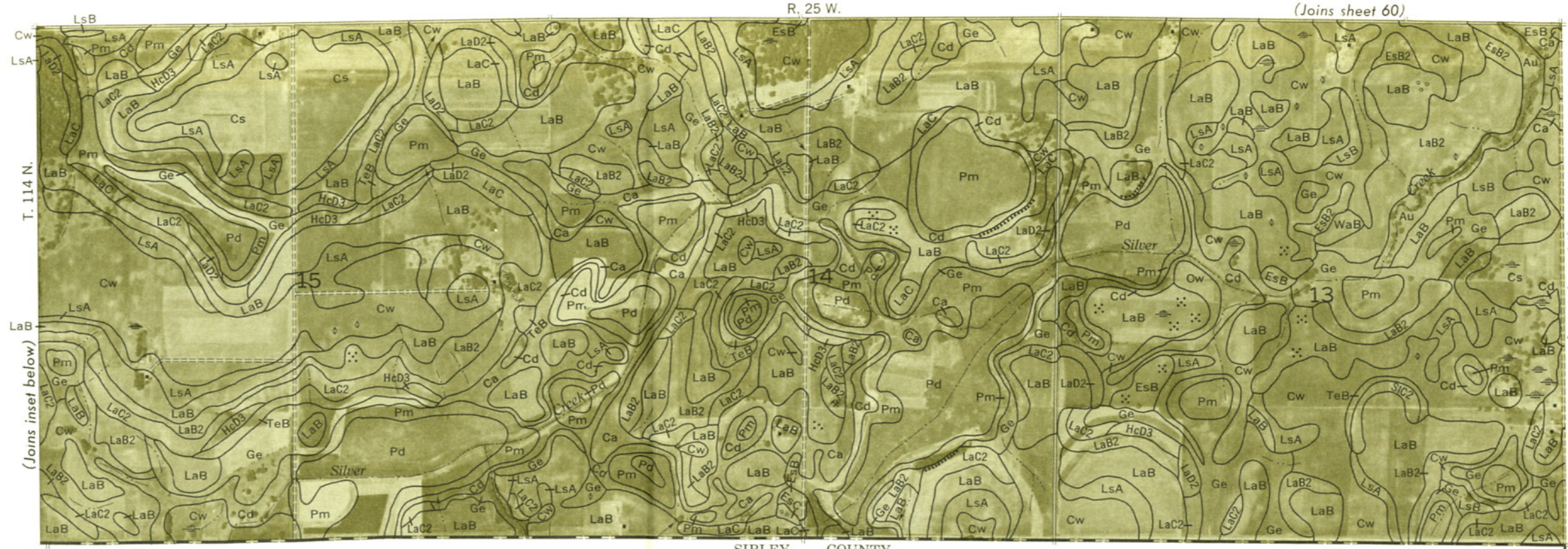
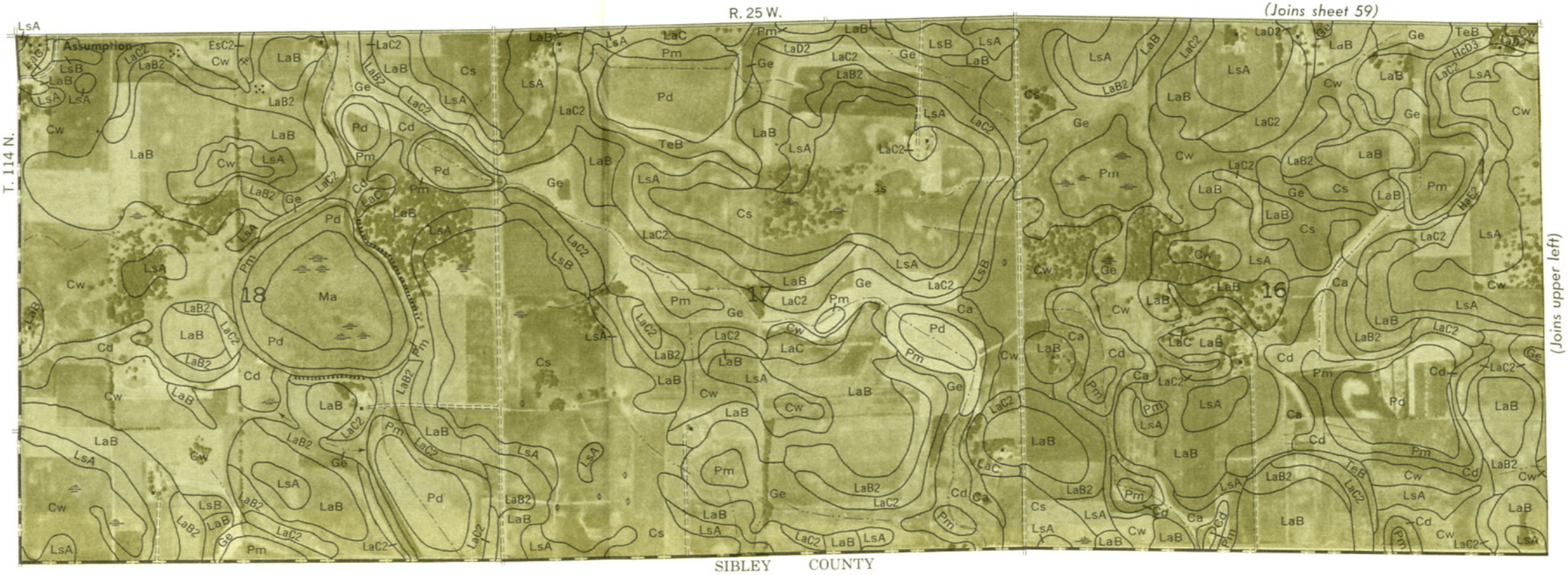
10
11
12


R. 25 W.
(Joins sheet 60)
T. 114 N.
(Joins inset below)
(Joins sheet 64)
N
15
14
13
Silver Creek
SIBLEY COUNTY

N


R. 25 W.
(Joins sheet 59)
T. 114 N.
(Joins upper left)
Assumption
18
17
16
Ma
SIBLEY COUNTY

64

N

(Joins sheet 61)

R. 24 W.

(Joins sheet 63)

T. 114 N.

SIBLEY COUNTY

SCOTT COUNTY

(Joins sheet 65)

(Joins inset, sheet 65)

SCOTT LAKE

JOHNSON LAKE

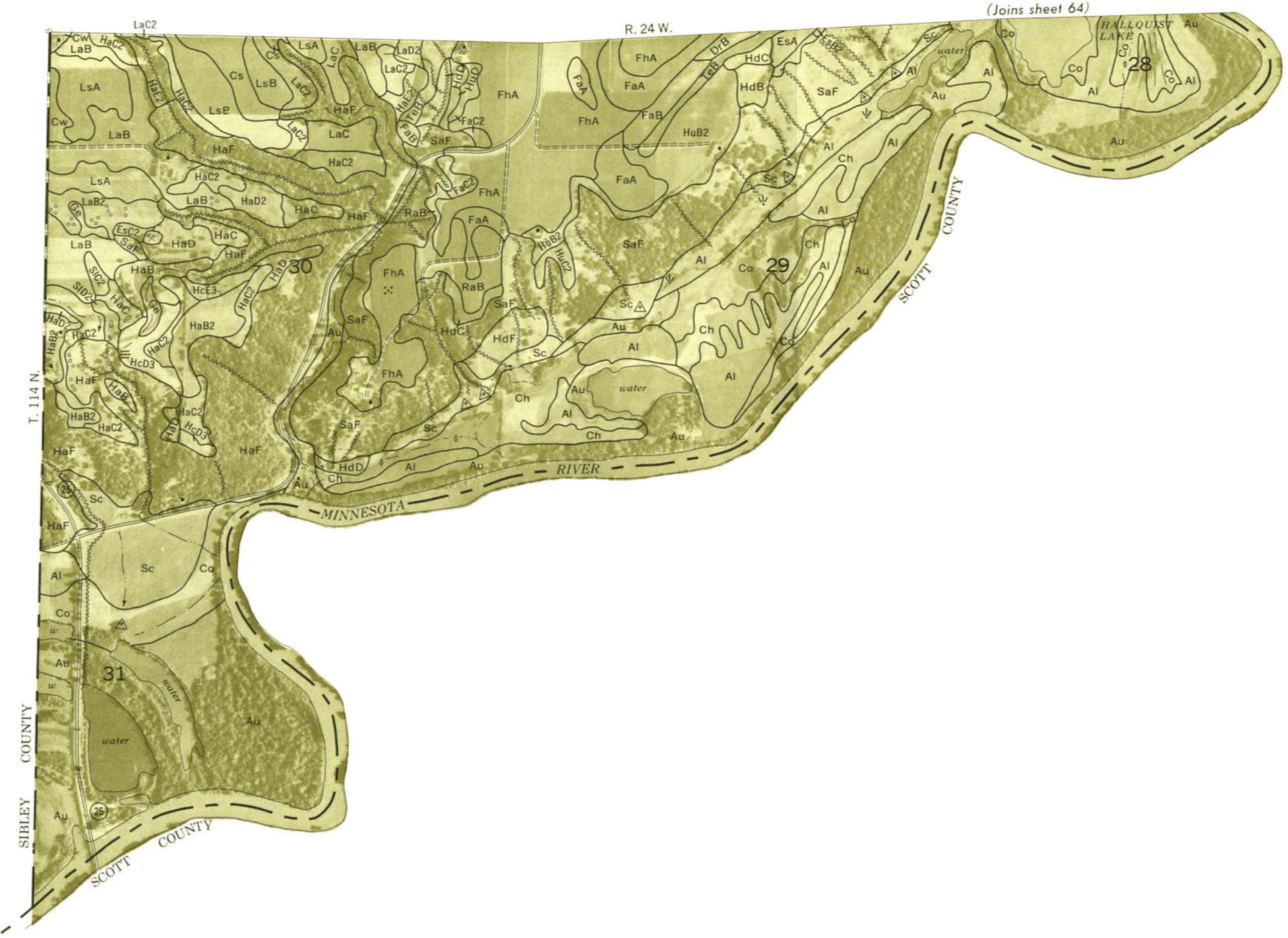
KELLY LAKE

HALLQUIST LAKE

MINNESOTA RIVER

16 17 18 19 20 21

CARVER COUNTY, MINNESOTA — SHEET NUMBER 65

65

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